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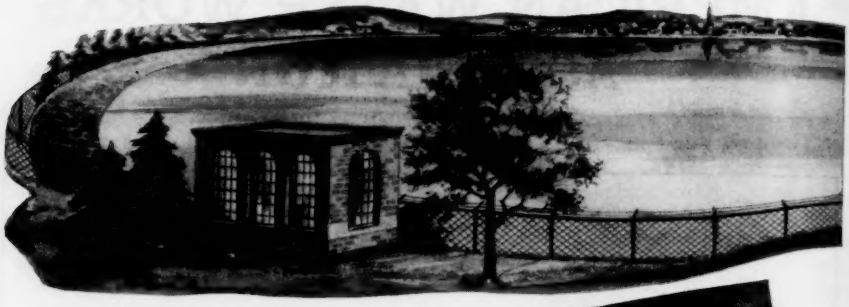

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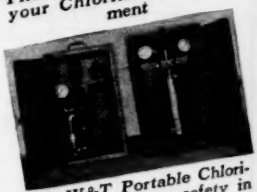

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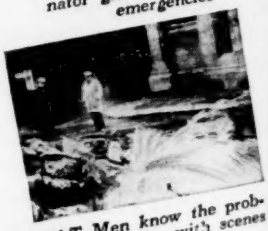

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Good Practice in Water Works Management

By Wendell R. LaDue

WITHOUT being labeled as such, there is probably no topic which receives more discussion among water works men than that which might be properly classified under the general heading of "management." Under this heading are usually discussed such subjects as factors affecting the continuity of employment of municipal water works employees, the diversion of water works revenues, means of improving the status of water works operators, adequate provisions for pensions and retirement, public relations, water rates, politics and promotions, the spoils system and many related and kindred topics. Most of the difficulties experienced in these various fields result from the basic fact that inadequate attention is given to the underlying fundamental reasons for their occurrence. In other words, time is spent in discussing the obvious *results* of bad practice in management, whereas something should be done about analyzing the equally obvious *causes*, diagnosing the resulting weaknesses, and then taking steps to correct them by well-known but neglected means.

In the present stress of wartime in the United States and in the post-war years to follow, the great need of the people of this country will be for trained and fearless leadership, free to provide the people with an intelligent and economical management of those activities which have become generally accepted as normal and routine. In no place will this be more essential than in the municipal utilities field and particularly that of water supply management. Even at present efficient leadership and progressive

A paper presented on June 23, 1942, at the Chicago Conference by Wendell R. LaDue, Chief Engr. & Supt., Bureau of Water & Sewerage, Akron, Ohio, and chairman of the A.W.W.A. Committee on Municipal Water Works Organization.

personnel are too often strangled and minimized by outside agencies and forces beyond the control of the trained utility manager and his loyal organization.

This situation was very forcibly brought to the attention of the Association by Louis R. Howson in a paper presented at the Indiana Section meeting in April, 1941.* In his discussion, he directed the attention of the A.W.W.A. Board of Directors to the problem; and at the June 1941 meeting in Toronto, as a direct result of this plea, the formation of a committee to study model forms of municipal water works management was authorized.

The committee of 25 selected to conduct an investigation of the situation found first that a large amount of research work would be necessary. To provide for this, each of the members was made responsible for the research into existing conditions and basic laws of a particular district.

Elements of the Problem

The basic and underlying thoughts looking toward improved management of municipal water works systems and the purposes and limits of the committee's activities are set forth in the following summary:

"Sound basic laws of the state or province under which the municipal plant must operate are the first and foremost necessity for good water works management. It must be honestly admitted, however, that poor management can and does exist under ideal basic laws. The reverse is likewise true—to the eternal praise of those rare individuals who thrive in adversity and have been endowed by a merciful providence with the patience of Job and the wisdom of Solomon.

"A uniform system of top management is not possible, or perhaps even desirable. Past history and local conditions must be considered, for it must be remembered that it is often hard to convince a public, satisfied with a bad old method, that it should adopt a *new* method, regardless of how good it may have been proved elsewhere. In general, the public gets what it wants, good or bad. A comprehensive study by this committee of the practicable alternatives in municipal water works management and organization set-ups, and the development of types of water works administrative control, which, with variations could be adapted to practically all conditions, will be a most constructive undertaking.

"If such a comprehensive study were available, prepared under the prestige of the American Water Works Association, it would be helpful in improving water works management in many communities. In that way it would be instrumental in improving the status of the water works em-

* Howson, Louis R. Management of Water Works. Jour. A.W.W.A., **33**: 1161 (1941).

ployees and in overcoming many of the ills directly and indirectly attributable to the general heading of management."

Although study by the committee will be confined principally to the water works field, thought will be given to the growing consideration of sewage disposal and, in some instances, garbage and refuse disposal and electric systems as municipal utilities.

Committee Organization and Personnel

Early in the study it became evident that the subject embraced a large field affected by varying backgrounds arising from the fundamental laws governing public water utilities in 49 or more political subdivisions in the United States and Canada. Therefore, it was evident that the personnel, distributed to cover the various sections of the United States and Canada, should be well versed in the question of top management and representative of various types and sizes of organizations.

Data for each state will be correlated upon receipt from A.W.W.A. members and others, reporting to the committee member by assignment; the committee member, in turn, reporting to the chairman of one of three geographical regions—Atlantic, Central and Pacific.

Aims and Limits of Committee Work

To prevent the overlapping of work of various committees and also to prevent the committee from wandering too far afield in its work, it became essential to establish a definite scope and limits to its activities. Therefore, the purpose was designated to be:

1. To limit the work of the committee only to the formulation of principals relating to forms of management
2. To avoid development of organization personnel charts
3. To limit investigation to municipal water works systems, except that the effect of combined water works and sewerage system operation must be kept in mind (NOTE: A feeling may exist that the inclusion of sewerage systems will complicate the problem to too great an extent. When it is considered that in a rapidly increasing number of cities joint management or joint collection of accounts is practiced it is evident that the question cannot be ignored entirely. In many states, as in Ohio, many water works managers are operating departments of "new and used" water. Management of such a combination department links the public utility viewpoint to that of a hitherto municipal functional service, in a somewhat conflicting admixture of operating, planning and personnel problems.)
4. To study existing state laws, determining, in each instance, permissible forms, extent of state supervision, economic freedom and political freedom.

Contemplated Activity

To give impetus to the committee work, a questionnaire has been developed, simple in form and wherever possible providing for yes/no answers. This questionnaire covers:

1. General statistics to determine size of plant
2. Form of city government
3. Form of utility management
4. State or province law under which the utility operates
5. Extent of state or province supervision
6. Financial organization and control
7. Opinions as to desirable change.

Careful thought was given to the distribution of the questionnaires, limiting the number to fifteen in any one state or province and selecting the cities in such a way as to secure a true cross-section of the various organizations, both large and small.

These organizations covered several forms, depending upon the size (volume) and extent (territory) generally operating under the following general groups:

1. *Metropolitan districts, including several municipalities:* Here the question of taxation enters. The unit is also a state subdivision, larger than the municipality. Excellent examples exist, admirably situated to carry out more or less peculiar situations of extended population demands.

2. *Board or commission organized within a single municipality:* These bodies are organized to handle the utility, independent of the general city government. Here the consideration is one of financing and especially credit. The question of mortgage-revenue bonds as against city general obligation bonds is a main issue. Such commissions usually consist of three to five men with overlapping terms of such lengths that no one political administration can upset them by a majority of new appointments. Their efficiency of operation rests on the fact that they owe responsibility to none but the general public, which they can and do serve. Being outside of a general political administration, continuity of service is assured, and, serving in a somewhat advisory position, they will attract representative citizens from various walks of life who are interested in the civic welfare of the community. These commissions or boards are in a position to establish a high standard of operation and efficiency. As Mr. Howson, in his discussion, so ably phrased it:

"This form of management lends itself to a continuity of employment; maintenance of high efficiency; establishment of constructive policies as to construction, operation and rates which continue without changing, except

as conditions warrant; and the furnishing of the consumer with a maximum of service at a minimum of cost."

3. *City manager and commission forms with many variations:* Briefly, this type of management, as it affects water works, is definitely limited by the capability of the city manager. Many smooth-running water works organizations have been deprived of excellent leadership by a city manager who thought he was selected actually to perform the managerial duties of all city departments without the assistance of tried and capable public servants.

4. *Mayor and council form:* In this, the main question is freedom of action and the necessity for segregation of funds for use of the utility only. The personnel of city councils is shifting continually, with the result that any centralization of top authority is slight. There is great danger that expedient "present" policies will prevail over efficient "future" or long-time policies. It is to be recognized and remembered, however, that a large majority of water works organizations now are operating under this form of government. Many excellent examples of successful operation under this form already exist and are models of efficiency under outstanding personal leadership.

5. *Small city and village one-man organizations:* These are simplified forms of item 4 and reflect both the good and bad qualities. Such an organization deserves good management just as does the large plant, and is as essential to community welfare.

The returns from the questionnaires have been very satisfactory, some 45 per cent of those addressed having replied.*

A preliminary examination of the questionnaires indicates a general expression of confidence in the board form of management, independent of the regular municipal organization. The committee plans to bear this trend in mind in carrying forward its study during the coming months. The practical fact must not be neglected that probably a large majority of water works systems operate, and in all likelihood will continue to operate, under the mayor-and-council and one-man organization forms. Consequently, very serious studies will be made in the various states looking toward improvement in the status of water works management possible and feasible under these forms of municipal organization. This will necessitate the examination of existing state laws, looking toward revision of the existing code or the enactment of enabling legislation to gain the desired purpose without revision of the existing fundamental form of management.

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* The committee should like to take this opportunity to request that those who have not yet returned their questionnaires do so as quickly as possible.

Summary

The water works profession will do much to improve its own status if it can effect a better top management. Too often, public opinion rules that the water works manager is doing a routine job in handling daily occurrences and that a plant, once started, grows of its own initiative. This, then, must give way to the true facts which dictate that good management will result only when *continuing* policies are allowed to develop and to thrive. The results of such policies definitely are adequate facilities, good operation, practical maintenance, logical replacement and expansion, sound fiscal methods, satisfying public service, reasonable provision for the future and all-round efficient administration.

Present and future needs and problems must be conducive to and met by careful, economic and sound planning both as to design and financing. In other words, sound management cares for the needs of the present and protects and insures the hopes of the future—a truly honorable undertaking, worthy of the water works profession and a challenge to all so engaged.

Sound Management and the Qualifications of a Good Superintendent

By Dale L. Maffitt

1. Some Principles of Sound Management

A WATER works is an important business organization. It is an important business from the point of view of service rendered, of plant investment and of labor employed.

Every person in the nation, rich or poor, requires pure water in order to live. Except in rural communities, this water is furnished through a system of pumps and distribution lines, the size and extent of which depend on the size of the community supplied and the concentration of population.

Industrial concerns require water in varying amounts in connection with the manufacture of goods. A rising standard of living, with its increase of various goods available to the individual, calls for an increase in water supply to meet increased manufacturing needs.

Now that the country is at war, it has been found necessary to concentrate the nation's moral and economic strength on the production of war materials. This has necessitated the building of arms manufacturing plants, airplane and tank factories, and the conversion of existing factories to the production of war goods.

Where new plants have been constructed the government has made a careful check to insure adequate water supply before plant location has been approved. The operation of these plants will mean a considerable increase in the use of water, and water plants must be prepared to meet the demand.

Water works can be classified as "big business" in the United States. It has been estimated that the 12,000 organizations in the country provide a wholesome and essential product to more than 80 million people. The annual income of these organizations approximates $450,000,000 and they employ over 60,000 people. These figures serve to emphasize the fact that

A paper presented on June 23, 1942, at the Chicago Conference by Dale L. Maffitt, Gen. Mgr., Des Moines Water Works, Des Moines, Iowa.

a water works is a real business, comparable with any industrial concern organized for profit. It is logical, therefore, to assume that the management of a water works should be chosen for ability, just as is the management of industry.

If a water works is to operate smoothly and efficiently with a minimum of waste, if it is to have sufficient income to provide for proper maintenance, operation and amortization of debts, the man in charge must watch expenses and estimate receipts. In making such estimates he may do well to overestimate expenses and underestimate receipts. Some unexpected emergency may arise to take up any excess revenue.

In addition, he must plan for the future. Funds must be available for expansion to meet increasing needs; and good business requires that these needs be met out of revenues rather than by increasing indebtedness. This means sound planning for the future through co-ordinating present charges for the product with present cost of operation plus a sufficient reserve for emergencies, improvements and the possible increased needs of future generations.

Benefits of Public Ownership

According to R. E. McDonnell,* approximately 73 per cent of all water works organizations in the United States are publicly owned. He suggests that in the case of municipal ownership the public is the beneficiary of good management through reduction of rates, while in the case of privately owned water works good management assures profit to the stockholders.

In connection with rates it might be well to suggest that planning reserves for future needs should be fully considered by management before any rate reductions are made. In Des Moines, for instance, it would not have been possible, on six months' notice, to complete a $100,000 water line to serve a United States ordnance plant if rates were adjusted so low as to take care of operating expense alone. Such emergency construction has been necessary in many places within the last year.

The public also benefits from municipal ownership in that water mains are often laid and services maintained in sections of a city which, because of location or of few service connections, actually do not result in a dollars and cents gain to the company from the standpoint of new revenue, but where the improvement to the community as a whole, in respect to sanitation and property development, gives a satisfactory return that would not be acceptable to the stockholders of a privately owned water works.

In well operated plants the public often gives little attention to the operation of the property unless an emergency arises and the consumer finds that he has no water.

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* McDonnell, R. E. The Engineer Looks at Management. Jour. A.W.W.A., **32:** 923 (1940).

Where water works are privately owned, the stockholders, through their board of directors, insist on good management in order that dividends may be forthcoming. In the case of municipally owned water works, the public may express itself, and does, when it appears that management is not effective.

Administrative Organization

In connection with the problem of choosing an efficient superintendent for a municipally owned water works it is necessary to note the system or plan under which the water works operates in relation to the municipal government. In an article on management of water works, Louis R. Howson* discussed this problem, suggesting that, in cities where the water works management is directly under the city council, the personnel of which is constantly changing, there can certainly be no long-range planning. The superintendent is subject to change with each change of administration, and consequently there can be no real responsibility or continuous policy.

There is a growing tendency toward the city manager type of government, but, unless the statutes are so written that water works management is removed from the direct supervision of the city manager, trouble may develop. Too often the city manager feels that he himself must have direct control of the operation of the water works, for the sake of centralization, and consequently may dispense with the services of an efficient executive trained in water works matters. This in time results in a deterioration in service. Water works management is a specialized service and cannot usually be efficiently combined with other municipal operations.

It is Mr. Howson's opinion that the most satisfactory form of water works top management is that of a commission or board, usually consisting of three to five men with overlapping terms of office of such lengths that only in exceptional cases can one political administration name a majority of appointments. Such a board is responsible to the public which it serves. It is non-political; its continuity is assured; and it attracts to its membership qualified men. Under such a commission, continuity of employment is assured, efficiency is better maintained, and long-range constructive planning is possible.

Management at Des Moines

The water board as a factor in good management has been demonstrated in the purchase and organization of the water works in many modern communities. The administrative body created at the time the city of Des Moines purchased the water works in 1919 was removed as far as possible from the pressure of politics. A board of trustees was selected for initial

* Howson, Louis R. Management of Water Works. Jour. A.W.W.A., **33**: 1161 (1941).

staggered terms of two, four, and six years, and subsequent six-year terms. This system of appointments was designed to permit greater stability in administrative policy and to aid in removing the choice of personnel from political domination. At that time it was decided that the individuals who had operated the private utility were fitted by temperament, as well as by experience, to serve a municipally owned utility. All private enterprises appeal for patronage not only through efficient service but in courtesy, and it was felt that the municipal body must of necessity render the same efficient and courteous service.

The Des Moines water board at the time of organization made the plant manager responsible for the selection and supervision of all employees, and the assignment of their duties. It has been the continued policy of the board to give the manager complete freedom in his action by avoiding demands for favors in appointments.

The welfare of employees has been considered both in regard to wages and in giving consideration for illnesses and accidents. These policies have resulted in a notable permanence in personnel, as evidenced by the fact that of the 149 regular employees, 31 have been with the Des Moines Water Works 20 or more years; and of the remaining 118 employees, 64 have been with the company more than 10 years. The average age of all employees at the Des Moines Water Works is about 43.

The policy of the management in its efforts not to show favoritism, but to be fair in its dealings with its employees and to be reasonable in its demands, has served to develop a marked loyalty to the organization among the employees. For instance, on February 26, 1936, at 5:30 in the evening, a bad break occurred in an important feeder main, leaving a considerable portion of the city without water. All but the emergency staff had left the plant and only one or two employees could be reached because the telephone service had become jammed. Despite this, within 45 minutes more than 20 people were at the plant, some from departments other than maintenance, ready to do what was necessary. The water service had failed in their homes and their first thought was that it was their company and their responsibility to repair the service.

2. Qualifications of the Superintendent

When, because of death or retirement of a water works superintendent, or for any other reason, a water board or commission must select a new superintendent, it would seem that principles of good business should apply. In considering the selection of a superintendent, a water board must have clearly in mind the type of service that a water plant should render. Then the problem resolves itself into finding the man whose character, ability and training indicate that he can manage the plant in such a way as to render the service desired.

In water works business, it is service that must be sold. The water is there for anyone to help himself. It is one of the economic free goods. But a modern world considers supplying water as filling a public need and has demanded the service of having the water delivered at the turn of a faucet. Experience has shown that the more efficient and courteous this service is, the more return in dollars and cents to the water works, as well as in goodwill toward the utility.

Technical Training

The man selected as a water works superintendent must know something about the technical operation of a water works. He must know something about water works chemistry and engineering. It seems logical to assume that he should have had experience working for a water works in a responsible position, so that there may be some evidence that he has training and ability. Since he is to be a manager he must demonstrate that he has executive ability. He must be able to do constructive planning and to give the orders that will insure that plans will be carried through to completion. His previous knowledge of the problems involved in water works operation should enable him to plan reasonably and sensibly for future needs and improvements.

The solidarity of the whole water works organization will greatly depend upon co-operation between the water works superintendent or manager and the employees as a whole. The effective superintendent should become acquainted with all employees on the staff, to the end that he may know their qualifications, such as education and ability, in order that they may be advanced if an opportunity arises.

A water works superintendent must be qualified to determine conditions of sanitation and must lean backward on all matters of judgment where it is so very important that the water that is being dispensed through the meters be completely free from all forms of disease-producing bacteria.

Responsibility to Public

A water works should be conducted in an orderly and systematic manner. The manager should insist that employees develop habits of cleanliness and orderliness. This is important from the viewpoint of sanitation and has the additional function of speeding up work, because tools and materials can thus be made available more quickly. The plant itself should be kept spotlessly clean. It is just as possible to keep motors and pumps polished and clean as it is to keep office furniture dust-free, and it is just as important. All buildings, grounds, tools and machinery connected with the service of delivering water should be maintained in such a way as to suggest absolute cleanliness and purity in the finished product—the water at the tap.

The old theory of having a water plant behind a six-foot fence, where no one can see it, is no longer accepted. Under ordinary conditions the modern water plant and grounds should be open to public inspection at any time. Now that a state of war exists, certain restrictions must be made; but in normal times people are naturally interested in the function of water service, since water is of such major importance in life. They should be advised about the problems of operating a water plant and the importance of carrying out constructive plans in connection with future needs.

If the public feels free to visit the plant and learn about its operation, it follows that the public will develop a pride of ownership in the plant and a constructive interest in seeing that its service is maintained at a high level. The manager should welcome such public interest and should encourage his employees to be courteous and friendly in all their contacts with the public.

A water works must be operated systematically. It must be operated 24 hours a day. Service must not be interrupted. The householder whose service develops a leak in the middle of the night is likely to call the water department for assistance and he should receive immediate and courteous help. In the broader sense, hundreds of functions of a modern city depend on the continuous operation of the water plant, and a whole community is affected if water service fails, through the interruption of other community services.

Ability to Organize and Plan

A water works manager should have vision, foresight and imagination. He must be able to project himself into the future, see problems before they arise, and perhaps, by careful planning and action, prevent trouble. He must have a sense of the public pulse. He must be able to know how the public will feel about things in relation to the water works. His contacts with all classes of people must be tactful, sympathetic and courteous. He must have a real interest in the other man's problems with the idea of seeing him through if he is in trouble. In this connection he must be consistent and fair in all dealings with employees and with the public. Certain rules and policies must be established and followed in the interest of company and community welfare. The unusual problem can always be worked out without making exceptions to policy if there is mutual courtesy and co-operation.

A competent water works superintendent should be able to take as well as give constructive criticism. He should surround himself with intelligent people who can carry out the details of conducting the business efficiently and on a high plane. The contacts of the employees with the public should reflect the same courteous and systematic service that the water board, through its manager, desires to render to the public.

It is impossible for a superintendent to make all contacts with the public personally or to handle all details of operation. His time and energy must be given to co-ordinating the operation of the plant as a whole, to planning ahead for future demands in service and to keeping in touch with public trends and demands for improved present service.

The superintendent must know what is going on, but should delegate the responsibility for the actual work, in respect to detail, to men and women whom he can trust to carry out his policies. He should be able to feel that the functions of the plant will be conducted in the same efficient manner when he is away as when he is at his desk.

The water works superintendent should keep pace with modern methods of operation and should be acquainted with new and different developments to improve the quality of the water.

Today, due to many modern refinements in our way of living, there is a growing tendency for the water consumer to demand a product of high quality from the standpoint of purity and potability as well as a water free from elements such as hardness-producing minerals and conditions that bring about disagreeable odors and tastes.

The modern water works superintendent should keep abreast of new ideas in his field through reading current literature on water works operation and should follow scientific developments in water works chemistry.

If a water board selects as a superintendent a man with these ideals of service who is capable of putting them into effect, and if the water board co-operates with its superintendent in his management of the plant and in planning for present and future needs, the result should be an efficiently operated water works to which a community may "point with pride."

Jonesboro's Water Works—A Successful Business

By Lloyd M. Rebsamen

JONESBORO'S water works business dates from July 1, 1906, at which time property owners of the city of Jonesboro through the proceeds of a $280,000 bond issue purchased the privately owned water and electric plant and, with the balance of the money from the bond issue, started construction of a sanitary sewerage system. The institution is now known as the City Water & Light Plant, and is a combined utility which, under one management, supplies electricity to Jonesboro and Nettleton, and provides water and sanitary sewerage service to Jonesboro.

Throughout the 36 years since that time the record of the City Water & Light Plant has shared in the progress of the city. The city's population has grown from less than 5,000 to 12,000; and water customers have increased from 853 to 3,260.

Rates for water and elctric service in Jonesboro have been so low that in comparison with average rates throughout the Southwest during this period, they represent a saving to the plant's customers more than equal to the plant's present value of $2,500,000.

This record has not been achieved without foresight on the part of those citizens who in 1906 started the organization. Those men saw that a water, electric and sanitary sewerage system could be owned by the public and operated successfully and for the public benefit if controlled by carefully selected business men who had an above-average interest in the community and its welfare and who, because of their faith in its future possibilities, had invested their savings in their individual businesses and their homes. Such property owners have an interest in the welfare of their community, because of their investments, that cannot usually be attributed to tenants. Because such property owners are unusually safe voters, in 1906, when the three original improvement districts were organized, the right to vote on the proposal was limited to owners of real estate within the limits of the proposed districts. In the subsequent elections of directors voting was again

A paper presented on June 24, 1942, at the Chicago Conference by Lloyd M. Rebsamen, Mgr. & Engr., City Water & Light Plant, Jonesboro, Ark.

limited to owners of real estate, each owner receiving one vote for each dollar of improvement district taxes paid during the year in which the election was held, the improvement district taxes having been levied for the purpose of retiring the original $280,000 bond issue.

So successful was the subsequent operation of the three improvement districts that no taxes were levied after 1919 and that during the thirteen-year period before that only nine and one-half assessments were made.

Due to the fact that no taxes were collected after 1919 the manner of voting for directors of the three districts was changed by legislative act to allow one vote to each property owner for each dollar of state, county and city taxes paid on real estate within the districts. In this way only those who show their interest in the growth of the city by owning real estate are given the right to say who shall direct the management of the City Water & Light Plant. The authority of the directors has been broadened from time to time until at present the plant is managed almost as freely as are most private corporations.

Combination of Utilities

By act of the legislature in 1921, the three original improvement districts were combined. The assets and liabilities of the three districts were pooled into the present institution known as the City Water & Light Plant. Each of the three original districts had been governed by a board of three directors, one of whom, for each district, was subject to election or re-election each year. From the first, for convenience and efficiency in operation, the three districts had operated as one and the three boards, as one, appointing a manager who operated the three utilities. When by legislative act the three boards were combined there was only a minor physical change in the organization. The three boards became one board of nine members, each serving for three years with three members subject to election or re-election each year.

The board of directors meets once each month with the manager in regular meeting and, when the occasion demands, in special meetings. The board functions much like the boards of private corporations, going over the affairs of the plant, directing its general policies and approving expenditures. For this duty each board member receives the sum of $6 for each regular meeting attended, or an annual total for all members of $648.

Benefits of Combined Administration

Out of this combination of utilities has come a complete utilization of the advantages of each system by the others, permitting the most economical operation of the system as a whole. If for instance, only a water system were being operated, it is probable that those in control of that system

would not have realized that power requirements for water pumping loads can and do become a serious detriment to the system supplying electric power. In many cities, however, water pumping loads coincide with peak loads on the electric system, making it necessary for electric utilities to provide additional facilities to handle these water pumping loads on peak. This was the case in Jonesboro, but happily, the solution was within the control of the utility itself. A study had been made of ways and means of bettering the power plant load curves. The design of certain types of rates to encourage use of electricity at other than peak load periods was of help, but was not sufficient to accomplish the purpose.

In looking for other ways to improve the power plant peak load condition the fact became apparent that the water plant was the worst offender. Because of inadequate elevated water storage, pumping was largely on peak with the electric plant peak load. Since water is the only product produced by the utility that can be stored to advantage, some method of accomplishing the purpose by addition to elevated storage was sought. The result was the purchase and erection of a $1\frac{1}{2}$-mil.gal. elevated water storage tank, put into service in November 1940.

By this addition it was possible to drop approximately 300 hp. of water well and circulating pump motors from the on-peak period and to fill in the valleys of the electric plant load curve considerably. This release of electric plant capacity at this time is most important because of wartime restrictions on materials. It is most fortunate that this addition to the water system, as well as other betterments, was provided well in advance of the present emergency. In addition to a release of electric plant capacity, the elevated tank also made possible a much more even water pressure, with an overall reduction in power consumption.

Needless to say the Arkansas Fire Prevention Bureau made a complete survey of the effect of the new tank on the system and found that its own anticipations had been exceeded. The utility is now enjoying that most coveted rating of having the only Class 1 water system in the state. The new tank is all paid for; no outstanding bonds need be paid off; the system has been given highest obtainable rating; and improved service and more efficient operation of the two utilities have obtained. In short, the project has proved an unqualified success.

This is only one of many examples of the value of combined operation. Regarding others, it is sufficient to point out that all departmental barriers are broken down in order to get the job done. True, every employee has his own regular work, but, in addition, wherever a job must be done, all employees are subject to call. If pressure is on one department and help is needed it is usually obtained from the other departments so that all are continuously employed. This makes possible a small, well trained,

efficient organization in which every man is someone's helper at some time. Its cost to the rate payer is much less than would be necessary for three separate organizations.

Combined operation, in this case, makes possible freedom of action without "red tape" and permits the management to make decisions quickly and without the delays incident to the usual type of political or absentee management. The management has authority to take whatever action is necessary to improve service and efficiency, and, therefore, to increase profits.

Although the City Water & Light Plant operates as a single utility, separate accounts are kept for each department. The water and electric departments are earning departments and the sanitary sewerage department is non-earning.

Rate Reductions and Contributions

Water rates in Jonesboro are low in comparison with other rates of Southwest cities. The Jonesboro rate starts at 90 cents for 3,000 gal. and slides to 18 cents per thousand for all over 303,000 gal. used per month. The first 303,000 gal. cost only $44.10. Arkansas's largest city delivers 10,000 gal. for $4.00. The Jonesboro plant delivers it for $2.79, and for good measure throws in sanitary sewerage and other services for which there is no further charge to customers. Other services include fire hydrants on every corner, water for fire fighting, water to city departments and a voluntary 18-mill school tax. In addition to these services the plant as a whole furnishes electricity for the street and whiteway lighting and for city departments; decorates the main street during the holiday season; has donated two fire pumpers to the fire department, has donated the sponsor's contribution towards a $50,000 stadium for the Junior High School; and has enabled the purchase of the former Baptist College property for use as a new high school by advancing $25,000 for property worth $250,000.

During July 1941 a new $210,000 sewage disposal plant was placed in operation. This plant is modern in every respect and is so efficient in operation that it is rated highest in the state for B.O.D. removal. The cost of the plant was met from funds accumulated for this purpose over a period of years. The new sewage disposal plant and the entire sewerage system will operate without charge or tax and will derive their funds solely from surpluses of the water department.

These services are not offered to the city to offset taxes since their value is many times in excess of a fair tax charge. They have always been supplied by the plant to reserve city revenues for the expenses of the fire, police and street departments. As a result, taxes are low, streets are in fine condition and adequate fire and police departments are maintained.

The installation of the sewage disposal plant and the elevated water tank, as well as a new steam turbo-generator and switchboard at the electric plant, completed a series of improvements that put the City Water & Light Plant in the fortunate position of having provided, in advance of the present emergency, equipment more than adequate to furnish the needs of the city during the duration of the war.

To clarify the situation it should be pointed out that the more than $625,000 spent for improvements during the past four years was provided from available funds plus earnings during the period. No loans, bond issues, or grants of any kind were necessary. In fact, during this period, appreciation of the market value of the investment fund and interest received almost paid for the elevated tank ($72,000). Cash and United States Government bonds on hand now total over $200,000.

The plant also has an enviable record of electric rate reductions, having made eleven over the past twelve years. The Federal Power Commission reports that Jonesboro's electric rates are the lowest in Arkansas.

The water system is a grid system of cast-iron pipe and copper services. Every service is metered. Water is obtained from new gravel-walled wells, requiring, as a precaution only, a slight treatment with chlorine and ammonia. The wells are pumped to two ground storage reservoirs. Two pumping stations, one in the power plant, circulate water from these reservoirs into the distribution system against the head of the new 1½-mil.gal. elevated tank which serves the triple purpose of leveling out the pressure on the system, maintaining sufficient elevated storage and permitting a reduction of peak loads on the electric plant by pumping off peak.

Finances and Depreciation

In the ordinary sense of the word, municipal plants operate without profit. It is necessary, however, that a municipal plant make a *net gain* each year to be used for plant renewals, extensions, etc. What the cost of service should be, taking these factors into consideration, is often difficult to resolve.

According to the opinions of the highest courts and of experts, assuming that service is necessary to the user, it is worth the honest cost of furnishing that service. Such honest cost is measured by rate schedules which will produce enough revenue to pay a municipal plant: (1) its operating expenses, including taxes; (2) a sum ample to maintain the plant in good operating condition; (3) an annual allowance for depreciation sufficient to compensate for the consumption of the property in service, to the end that the integrity of the investment in the depreciable property be not impaired; and (4) to pay a reasonable return on the value of the property comprising the instrument used in furnishing service, that funds will be on hand to take care of necessary extensions and improvements.

All property, except land, which is usable in the plant's service eventually wears out, or more frequently becomes inadequate or obsolete, and is, therefore, no longer capable of doing the work necessary. This property, be it buildings, machinery or equipment, must be replaced with new, more efficient, more adequate property. Hence, an annual obsolescence and depreciation of value, representing this wear and tear, must be made in such amounts as will, at the end of the useful life of the property, remove it from the asset accounts. This annual charge may vary from as low as 1 per cent of the original value of the piece of property to as high as 25 per cent or more depending upon the purpose for which it was originally bought and used and on its estimated life.

Charging off depreciation, however, is not enough unless there is set aside annually an amount of money equal, wholly or in part, to the amount charged off for depreciation so that, at the end of the useful life of the property, funds are on hand to represent the value of the property to be replaced. This money, together with additional money obtained from gain over operating, overhead and maintenance expenses, must then be used to purchase and install new and more adequate property. Then, the process continues, so that the plant is at all times capable of removing worn out, obsolete and inadequate machinery or equipment from service and installing in its place new, more efficient and more adequate property.

Pay-as-You-Go Financing

An examination of the balance sheet of the City Water & Light Plant will show that there are no outstanding debts of any kind and that there is on hand a fund, invested in United States Government bonds, which will make possible a continuance of the policy of making additions and replacements from available funds without the necessity of floating bond issues. Such available funds enable the plant to do almost twice as much work for each dollar of total cost as would be the case if the plant operated from borrowed money on which interest would have to be paid. This maintenance of a reserve is thought to be the soundest method of protecting the future of the plant. Net gains from operations, wisely reinvested in plant and equipment or held in reserve for such investment, allow the plant to grow and to meet the continually arising needs for more and better service.

At present there exists a critical shortage of labor and materials due to the needs of our war program. It is impossible to continue a normal program of water works construction. Prices for materials and the cost of labor have advanced, too, in many cases to the point where a pre-war dollar will buy only fifty cents worth of materials or labor.

Since it is now almost impossible to spend money for construction, a number of plants will find that they are beginning to pile up surpluses. Right now, then, is a good time to use this surplus for the retirement of

debt, for a dollar will still pay a dollar of debt though it buys only fifty cents worth of materials or labor. A program of debt retirement now should find water plants in much better financial position after the war. If a plant finds that it cannot buy in its outstanding bonds, surpluses can still be invested in government and war bonds to be held against the time when the bonds can be retired.

The writer has often been criticized by financially burdened operators for the fact that paying off debt at the same time as setting aside depreciation reserves constitutes double taxation of the rate payer. Possibly that is true but the advantages of a debt-free plant are too great to ignore. Bond issues serve a very definite purpose, but they should be paid off as soon as possible. The pay-as-you-go policy has often demonstrated its superiority.

The only unknown quantity in such a program would seem to be the question of whether the public has confidence in the ability of the water works management to handle its money properly. If they do not, plants must wait until service becomes so poor that the complaints finally make themselves heard in a bond issue that reluctantly permits the necessary improvements to be made now and *paid for twice* by succeeding generations. Stated in these terms, the choice is obvious.

To inaugurate a pay-as-you-go plan, an efficient and complete accounting system is necessary, that is, an accounting system which does more than just keep track of the money, one that will tell the operator the necessary facts regarding his progress or lack of progress. The latest and best applications of the science of accounting are none too good for the plant that wants sincerely to get on top and stay there.

Another factor in good management is freedom from political interference. In the Jonesboro system, the city does not and cannot touch the revenues of the plant. It has no financial interest in the plant. It does not appoint the board members or employees. It cannot dictate policies. The plant is a separate entity, which never has been, and, under its unique and sound plan of organization, can never be a political football. Efficiency is the keynote of the management and for a good many years the policy of the City Water & Light Plant has been to "supply service technically as good as the most advanced standards of the art and our financial and human resources can compass; operate so efficiently that we may be able by improved methods and increased sales to reduce unit costs and consequently lower rates; conform our policies to the ever-changing needs of our customers; keep in mind the social, as well as the economic aspects of wholesome water supply; plan and carry on our business so that we earn, deserve and obtain, not alone, the respect of the public, but also the public's good will toward us as servants entrusted with a vital job."

The Omaha Water Works—A Successful Business

By Walter S. Byrne

IN THE author's experience in privately-owned business and utility enterprises, it was always his belief that, to be successful, business had to make a profit. It was difficult, therefore, to imagine a well-conducted, prosperous, efficient public service institution that made no "profits" in the literal sense—and aimed to make none, except in the form of lower rates and improved service to customers. Yet, just such an organization is the Metropolitan Utilities District, which operates the water department for the city of Omaha.

In his early employment in the organization, the author made another equally amazing discovery—that the people of Omaha, and of Nebraska, expect their public debts to be paid when due, even if needed improvements and extensions must wait. Perhaps it is because of this passion for the payment of debts, public and private, that Nebraska has become widely known as the "debtless state."

It is rather amazing and altogether delightful to contemplate the philosophy and business practices which have made the Omaha water department such a successful public servant. It has been an enlightening experience to discover that men can work for ideals of service rather than for cash profit, to find that there is a self-gratifying incentive in building an institution which touches the lives of every man, woman and child in a metropolitan area, and contributes so much to their health, convenience and happiness.

This problem of creating enterprise without profit is one common to most municipally operated utilities. It can be solved by capable, non-political management. In Omaha there has been, from the beginning, a definite appreciation of the value of service on the part of all employees, from the management down. This desire to serve, to improve and to maintain a service comparable with privately operated plants has produced excellent results.

A paper presented on June 24, 1942, at the Chicago Conference by Walter S. Byrne, Gen. Mgr., Metropolitan Utilities Dist., Omaha, Neb.

Many persons have been prone to regard water service as a necessary evil, a thankless task—something that must be provided from public means much the same as street cleaning, garbage disposal and the like. But few of the employees of municipally-owned water plants think it is a business at all. Unfortunately, many customers feel the same way.

The public may have high regard for its gas, telephone and electric services, but water service is considered just something everyone must have. It is accepted, it is cheap, it is forgotten, it is taken for granted. Yet, despite the lack of appreciation, it is the most essential service of all. Nothing has so demonstrated this as the catastrophies of modern war.

Telephones, electricity and gas are conveniences that can be dispensed with in an emergency but water is a necessity. To be sure, these points are obvious, but they deserve emphasis to the unappreciative public. Water is cheap in the river or the well. What most people do not understand, however, is the huge investment, skill, management, vigilance and labor required to "process" that product, distribute it and to make it available in usable, convenient form.

The water works man is actually in the processing business. He takes a raw material from a stream, or a lake or a hole in the ground, and from that raw material he processes a potable, usable product and distributes it under conditions that make it available 24 hours a day to his customers, in their homes, offices and factories.

The importance of water has increased immensely in the modern scheme of living. It has stepped up from a lowly primitive state to take its place among the most useful public utility services in existence. This has come about through improved habits of hygiene and the development of such appliances as the bath tub, the automatic water heater, the washing machine, steam heating, irrigation, humidifiers, air-conditioning equipment, refrigeration, etc.

Early History of Omaha Water Works

In Omaha the water plant has always been regarded as a business. This tradition of business management has persisted and grown since the plant passed from private to public ownership 30 years ago last December.

The importance of an adequate water system was impressed upon the citizens of Omaha very early in the city's history. These early experiences made a deep impression on public consciousness—an interest that still remains almost undiminished.

In 1879 a fire destroyed the Grand Central Hotel, killed five firemen, exhausted the city's cistern water supply and aroused the public to the need for a better water system. From this awakening to a need has evolved Omaha's present $15,000,000 water plant and distribution system.

Omaha's first water works, the City Water Works Company, built settling basins, pumps and a station, and began pumping water from the Missouri River through its distribution system on August 2, 1882. Seven years later, a second pumping station was completed; but the company went bankrupt and was sold in 1896 to a group of Omaha business men.

Shortly thereafter, a movement for municipal ownership was started and after several years of bitter legal disputes as to the purchase price of the system, a bond issue was voted in 1909. This was found unsalable because of the low interest rate so another bond issue for $7,500,000 was voted in 1911. Ownership of the water plant was assumed for the city by the Omaha Water Board on July 1, 1912.

Organization of Utilities District

The Metropolitan Water District was formed in 1913 by authority of the State Legislature and given the right to furnish water outside the Omaha city limits, since South Omaha, not yet annexed, was being supplied with water. With the annexation of the suburban area of Benson in 1917, the district acquired the Benson Water Works. In 1922, the district's name was changed to Metropolitan Utilities District by legislative enactment.

The Water Department is now operated by the Metropolitan Utilities District as a department, under a charter of municipal incorporation granted by the Nebraska State Legislature. It is a separate political subdivision of the state, is entirely independent of supervision and interference by city officials and, by the wise provisions of its state charter, has been free of the political ailments and troubles found in many municipal utility organizations. In this respect, it is almost unique.

The district is conducted by a bipartisan board of six directors, each serving a six-year term under an arrangement whereby two directors, one from each political party, are elected by popular vote every two years.

With consistent wisdom, Omaha voters have selected utility directors from the best business and professional minds in the city. A directorship has never been considered a "political" office. As a matter of fact, the salary—$50 per month—is scarcely attractive as a political "plum"; and director's job is no armchair affair. The directors must give freely of their time and ability. They are *directors in fact*. About the only pay they receive is the appreciation of their fellow citizens and the satisfaction of doing a vital public service for their community.

Operations are delegated by the Board of Directors to the General Manager, and the organization is much the same as that of a privately owned utility. The powers and relationships of directors, management and employees are practically identical with privately operated enterprises in the utility field.

Management Principles

Certain simple principles have guided the directors, management and employees of the Omaha Water Plant:

1. That bond and current obligations be paid when due
2. That the water department be self-sustaining and self-operative
3. That plant, equipment and service be maintained at a consistently high level, with proper regard for future needs of the community
4. That rates for water be as low as possible, consistent with good and adequate service
5. That the best business and engineering practice be followed in every phase of the operation.

Strict adherence to these principles has not always been easy, as a few examples will demonstrate:

Debt Retirement and Rate Reductions

On December 15, 1941, the Metropolitan Utilities District retired all remaining bonds outstanding against the Water Department in the amount of $2,668,000 from a total original issue, at the time of the plant purchase, of $7,500,000. Throughout its 30-year history the Water Department has maintained that the bonds should be met in full as they became due and that no refunding operations should be admissible. As a result, the system is now free of bonded indebtedness.

This principle of paying one's bond debts on the dot, without refunding, may be old-fashioned but it has produced excellent results. It has not been easy, however. To meet debt service and bond sinking fund requirements, and, at the same time, to make eight water rate reductions, has been a struggle few except stout hearts would dare to tackle.

In addition to paying this debt, the district has more than doubled the value of the city's water works property, with improvements and additions built in the past 30 years. Meanwhile, too, the water system has grown from 25,590 water services in 1912, to a total of 55,530 today, and its distribution system from 245 mi. of mains to more than 600 mi. now.

Credit for this unique achievement must be given to the public as a whole, to the prominent Omaha citizens who have served so efficiently as directors of the district and to the executives and employees of the water department. All have had a part in the success of this civic enterprise.

When the city assumed control of the water works in 1912, the base domestic rate was 26½ cents per 100 cu.ft. Since that time, there have been eight reductions, so that the present base domestic rate is only 12½ cents per 100 cu.ft. On this basis, Omaha water users have saved more than $12,000,000 in water costs, in addition to which property owners have saved approximately $1,880,000 through reductions of hydrant rentals.

Administration of Hydrant Rentals

A comparison of the old and new fire hydrant rentals shows the saving in this essential service. The number of fire hydrants at the time the city took over the plant was 2,053, for which an annual charge of $60 per hydrant was made. Today, there are 4,832 hydrants and the charge is $117,500. At the old rates asked by the Omaha Water Company, the charge on the present 4,832 hydrants would be $287,220. In other words, the property owners have saved $169,720 in fire hydrant rentals in 1941 alone.

As in other cities, some agitation is manifest from time to time for complete elimination of fire hydrant rental. Although the directors of the Metropolitan Utilities District have seen fit to reduce the rental considerably, it has not been eliminated entirely because such an action at present would probably necessitate an increase in regular water rates for small consumers and because an elimination of the levy would transfer a disproportionate burden of maintaining water for fire protection on the small, individual property owner.

Fire protection is property protection. The city is taxed for the support of a fire department; but the fire department must have water to fight fires. Providing water for that purpose is a necessary part of the governmental duty of affording fire protection to property. Those who purchase water, purchase it for domestic use, or use which has no relation to fire protection. The Nebraska Supreme Court, in 1924, made this fact clear in a decision in which it declared that it is neither logical nor just to require water consumers to pay for the protection of property. The benefits received by consumers of water and by property owners are entirely different.

Studies by the department show that efforts by large property owners to shift the burden of fire protection to water consumers are constantly being made in cities everywhere. The greatest demand for fire protection service is from the congested high-value downtown districts; but the greatest production of water revenue is from the small owner and tenant in the residential districts. In Omaha, the hydrant rental, in principle, is not merely a method of securing more revenue, but a means of providing a logical and just apportionment of cost as between property owner and the water consumer.

Rehabilitation and Expansion Program

To meet debt requirements during past years, some improvements, replacements and extensions have had to be deferred. This deferment has made it desirable for the department to schedule a long-range rehabilitation and expansion program that will cost approximately $2,200,000 and will be completed as swiftly as it can be paid for out of income, and in con-

formity with a policy not to undertake projects if they hamper the nation's war effort.

These needed improvements will, if possible, be made without increasing domestic or industrial water rates, by utilizing funds formerly required for debt service. The eight principal projects to be undertaken as soon as conditions permit are:

1. New intake facilities to guard against low river stages at Florence Pumping Station, $250,000
2. New feeder and trunk mains in west and southwest areas to protect against future pressure and water shortages, $400,000
3. An elevated storage reservoir in southwest Omaha, $250,000
4. Cleaning and relining of trunk mains, $250,000
5. An additional covered reservoir, location undecided, $500,000
6. New trunk mains and inter-connections for the new reservoir, $300,000
7. Additional pumping equipment for booster purposes on mains not served directly with Florence pumping plant pressure, $150,000
8. Covering Walnut Hill Reservoir, $300,000.

All of these projects are needed, some of them are urgent. The work on the Missouri River intake at Florence is an urgency which cannot be ignored in the interest of essential public welfare. This project is an example of the type of work that must be carried on despite wartime limitations.

The technical capabilities of the department too have been strengthened considerably by the employment of a full-time bacteriologist and a taxonomist. One of the noteworthy results of their research has been the development of what is believed to be an improved method of bacteriological determination by means of a specimen-concentrator.* This instrument has made possible both quantitative and qualitative identification of organisms, the existence of which was not previously recognized. In the water works, as in other types of business, too much emphasis cannot be placed upon the necessity for improving the quality of product. It is believed that bacteriological control is one way in which this goal can be attained.

Effects of the War

War has brought its special problems, as it has to most individuals and most businesses, large and small. The specific wartime problems of the water industry are, for the most part, common to all water works.

Current operating conditions demand that the Water Department get along with the present plant and equipment, because additions are impos-

* Ford, Bruce R. and Gunderson, Millard F. Concentrating Filter for Large Water Samples. Jour. A.W.W.A., **34**: 585 (1942).

sible due to wartime regulations and high prices for labor and materials. To meet wartime demands on the plants and system it may be necessary to alter the consumption habits of the customers, especially in the regulation of non-essential uses. A common device, which has not yet been adopted, but which many already use, is regulation of domestic sprinkling. Load shifts can be effected by zoning of sprinkling, time limits, etc.

The Omaha Water Department faces the problem of maintaining efficient operating conditions under the handicap of shortages, higher prices and increased demands. Beginning early in 1940, a special effort was made to have sufficient materials on hand for emergency repairs in case of damage by air raids, sabotage, accidents and service interruptions from any other unusual sources. Plant and system protection from sabotage have been in effect for some time, with rigid identification routine and 24-hour guard service at pumping stations, reservoirs and other vulnerable points.

Omaha's system of fire protection is well conceived, especially for the downtown section of the city. A program of determining system capacity and cleaning trunk mains to improve carrying capacity in certain outlying districts has been carried on for some time.

The Missouri river intake, from which the raw water supply is obtained, has been seriously affected by drought conditions and river improvement projects. As has been mentioned, however, steps are being taken to insure adequate supply under all predictable conditions.

There has been established a wartime policy of deferring all major projects for the duration, where costs are unreasonable or materials not readily available, providing these projects are not absolutely essential to the safety and health of the community. Meanwhile, sufficient financial reserves will be accumulated to undertake necessary projects planned for the future.

Careful surveys of the distribution system are being made to determine the additional improvements to be scheduled during the next few years, if demands continue and the pressure of war scarcity is lifted. These surveys will enable a definite allocation of money and materials to needed improvements at the proper time.

Key executives have been organized into a War Council for considering special wartime problems and for the interchange of information and ideas relating to war conditions. This council meets frequently and is of great value in co-ordinating precautions, efforts and objectives.

Full co-operation with the Public Works Reserve has been established, with the object of enjoying maximum benefits from this agency in its programming of projects, long-range planning for post-war problems, etc. Close co-operation is also maintained with the various civil defense and war agencies in all phases of their work which relate to water supply.

In a nation at war, the water industry has more than ordinary responsibility, not only to the community but to the nation. This responsibility must be discharged by the best available methods and to the limits of its strength. It means that the industry must not only maintain service with the least possible utilization of vital materials, but it means that it must be prepared to meet interruptions, demands and urgencies far beyond those to which it is accustomed.

It would seem that the best possible preparation is the skill and spirit that come from years of sound, efficient business-like operation. In the field of private enterprise, a business sinks or remains afloat, only if its owners and managers have vision, integrity, courage, initiative, skill, and a warm appreciation of the needs of its customers. The same thing should be true of a public corporation.

The author is impertinent enough to think that the Omaha Water Department is as good an example of sound business practice as can be found anywhere. The people of Omaha have low water rates and a $15,000,000 water plant completely free of debt to prove it.

War and Water Rates

By Reeves Newsom

A CONCRETE appraisal of the effect of the war on water rates, the degree to which increases are needed and the success in getting them adjusted upward, must of necessity await the end of the conflict or at least a longer period of its duration than to the present. The forces which are at work—physical, financial and sociological—are so stupendous, so conflicting and so rapidly changing that any statistical study made at this time would become obsolete while it was being compiled.

At the 1918 Convention of the Association, a report was made by the Committee on War Burdens of Water Works in the United States,* which contained a considerable amount of data regarding the changes in costs and revenues of water systems from 1914 to early 1918. Having brought those statistics down to the end of 1918, the late Leonard Metcalf presented an illuminating analysis† of what had taken place, at the 1919 Convention, the first following the close of the war.

At the present time it may be of interest to consider the things we are now experiencing, their similarity to what happened in the last war and the differences in experience to be anticipated, as this war progresses, because of the changes in conditions and the evolution of civilization as we know it in this country.

One evident similarity is the time lag which occurs before the making of rate adjustments reflecting the increased costs to which water works are put. The *Public Utilities Reports* for the years 1915–18 reveal that, of a total of 98 increases granted to water companies, 4 were allowed in 1915, 12 in 1916, 15 in 1917 and 67 in 1918. Thus far, in the present situation, the writer knows of no increases that have been petitioned for on the basis of increased war costs. Certainly with the history of the past few years in the adjustment of utility rates and the scrutiny which is now

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A paper presented on June 22, 1942, at the Chicago Conference by Reeves Newsom, Engineer-Consultant, New York.

* Jour. A.W.W.A., **5**: 303 (1918).

† The Effect of the War Period 1914–1918 and Public Control Upon the Water Works of the United States. Jour. A.W.W.A., **6**: 785 (1919).

given such matters by regulatory bodies, at least as great if not a greater lag is to be anticipated in the present situation.

Furthermore, as was the case in the last war, only partial relief can be expected through rate increases and the major portion of the burden can be expected to fall upon the owners of water systems. As stated by Mr. Metcalf, the increases granted up to 1919 resulted in about a 10-per cent increment in net revenue, in spite of which, there was an overall net revenue decrease of approximately 10 per cent. Again, because of the even greater unpopularity of rate advances for utilities today, probably no better result can be anticipated.

The delay in getting adjustments made will throw them into the period when individual home owners will be paying the highest taxes in their experience. Many will be hard pressed to hold on to their homes, and, politically, the granting of increases is going to be very difficult for regulatory commissions.

Unique Features of the Present Emergency

There are, of course, many elements in the present situation that differ from that during the last war. One major change and one which will contribute to the postponement of the time when relief is needed, is the tremendous industrial activity which dwarfs that in the last war. War production, because of its immensity, has been spread far and wide over the country and a great many water works are experiencing large increases in their revenues. It is almost universally true that, in communities where large industrial activity is present, such revenue increases have fully offset the increased costs of operation and taxes as they have so far been experienced. To such plants the pinch will come when this activity begins to dwindle and when, in the meantime, costs continue to rise. There are many systems, however, which serve communities not directly involved in the war effort. In these, the margins between income and expense are already fast disappearing.

On the increased cost side are a number of differences because of influences and events which did not operate during the preceding war period. In the field of labor costs, it must be recalled that the war advances have been superimposed upon the costs of the bettered status of labor, much of which, so far as water works are concerned, were encountered just prior to the war and had not been reflected in the rates.

Unionization of water works employees has progressed rapidly in the last two years. It was not started by the war, but has had added impetus given it by the present conditions. Whenever a group is unionized, the organizer must show some benefit to the workers, and this benefit often averages as high as 15 per cent in increased wages.

In the water industry in general, vacations with full pay, even for hourly employees, is now the practice. While the Fair Labor Standards Act has not been accepted by many water systems as applying to them, substantially all are granting the benefits in the form of time and one-half for work over 40 hours per week.

To these costs for labor, which have not in most cases been reflected in increased rates, must be added those resulting from the war and the production of materials of war.

Fifth-column activities were not as highly organized in the last war as in this one. The costs for guards, floodlighting and other sabotage preventives have had to be provided for. Such costs are very high in some places. It is true that, in industrial cities, where the most danger lies, the water works are doing increased business, but the state of the public mind is such that even in communities where war work is not being done in volume, it has been necessary to make heavy expenditures for protective measures.

Further Causes of Increased Costs

The loss of employees through the operation of the draft has caused inefficiency and resulting higher costs of operation. In those localities where extensions of systems have been required and added personnel has been needed to meet the war demands in the operation of the system, water works managers and superintendents have had to compete for labor because of its scarcity, thus adding another increment to the expenses.

In the field of materials there are, of course, price ceilings; but, unfortunately, a substantial increase had already taken place before prices were frozen. Those increases are not reflected in the rates for water under which plants are operating. Furthermore, the piercing of ceiling prices is freely predicted, so that the upward spiralling of prices may have only been retarded or delayed.

Also in the field of materials, there is the priority situation. Most of the thought in regard to priorities has been devoted to the getting of materials and equipment needed and the various and constant changes in requirements that must be met. Priorities and their lack have been and will continue to produce increases in costs of operation. Not only is the time spent in making application and keeping records costly, but essential work of operation and maintenance must often be neglected. Furthermore, failure to get new equipment when needed means the continued operation of obsolete and inefficient facilities, often with the inefficiency accentuated because of overloads on the plant.

The inability to get proper materials and equipment leads, perforce, to the use of substitutes which either cost more to use or to maintain, or both, a condition which will get worse as time goes on. Thus, the costs of opera-

tion are creeping up because of priorities, another element leading to the need for water rate adjustments. The priority situation does have one saving grace which in fairness must be mentioned. It has saved many water works operators from having to yield to pressure to make unprofitable extensions into sparsely settled territory.

Variation of War Costs With Ownership

In two important ways, municipally and privately owned water works are affected differently by the present situation: in the provision of capital for improvements to meet war demands and in the effect of the heavy increases in federal income taxes.

Under the provisions of the Lanham Act, the Federal Works Agency advances the money required to reinforce distribution systems, to get new supplies, to build additional purification works and pumping stations, etc., where the war production demands form a disproportionate part of the normal output of the system. In many cases this is done on a contributory basis, the municipality putting up that part of the money which represents the cost of the portion of the works it needs or would soon need for normal growth. In some situations, a grant of the whole amount of money required is made to a city and the ownership of the new works is in the municipality. In cases where large supply projects, sometimes for more than one community, are required, the government finances, builds and owns the new facilities, selling water at wholesale. In such cases, operation may be undertaken by a lease arrangement with the principal community involved.

The result of such federal or partially federal financing of projects is to freeze the rates at present levels. In such situations, large additional revenues are derived from the war business, which was the justification for the government's participation. Reduction in rates might be feasible from this larger volume of business, but the government does not allow the citizens of a community thus to get the benefit of its financing the new works. It looks to those revenues as the basis for the municipality's contribution to the first cost or as the basis for reimbursement after the war is over for works which it has fully financed.

This procedure is not open to privately owned water systems. Regulatory commissions have, in a number of cases, been instrumental in requiring the industries needing the additional water to put up part of the cost of the new facilities, such moneys to come from government grants for extensions to their plants or from the payments made for the products manufactured. In other cases, where the private utility has been able to furnish the money, special increased rates have been authorized, sufficient in amount to amortize the investment in a period of five years.

Increased federal taxes are, of course, the largest single wartime financial problem of the private water company. Although thus far no settlements of this problem have been noted, preliminary discussions with commissions have indicated a reluctance on their part to allow a water company to increase rates to offset increased taxes, certainly not to the full extent. This attitude is no doubt connected with the conception that one of the purposes of high taxes is to prevent inflation and if the same were fully offset by increased charges, and such a practice were widely applied, that purpose would be defeated.

Obviously some solution to this situation must be found, inasmuch as high taxes superimposed on all other war costs will seriously threaten the character of a service vital to the community and might even bankrupt a company which does not get compensating increased volume of business from war activities.

Many of the forces at work are thus seen to be conflicting and constantly changing. The net effect on water works revenues cannot now be foretold and will obviously vary with different plants. The development of a solution to the problems of getting increased rates to insure proper and adequate service at a time when individuals may be carrying back-breaking taxes and, in many cases, facing disaster in their business and homes, is one of the major tasks facing the members of the water supply industry and profession.

Promoting Conservation of Water by Rate Surcharges

By Frank C. Amsbary Jr.

THE recession of ground water levels throughout the Midwest has been observed by those interested in public water supplies for at least a quarter of a century with a feeling of grave concern. Until recent years the attitude of the public has been one of complacency.

The Champaign-Urbana water utility has been in an unfortunate position. Every warning sounded by it has been viewed with askance. The public's feeling has been that the water in this area comes from an inexhaustible underground lake and any plea for conservation would only be interpreted as a subterfuge to hide some other deficiency.

In addition to the general apathy of the public, the problem in this community has been made doubly hard because of operation under private management which necessarily places all rates, regulations and policies under the jurisdiction of the Illinois Commerce Commission. No difficulty with the commission had to be feared, if the proposition to be presented was equitable, could be supported by fact, and if the public, which the decision would affect, did not oppose.

Data kept by the company showed the decrease in available supply, but convincing the public of the necessity for conservation was the big problem. It was felt that before any method of conservation could be submitted to the commission for consideration, the public affected must be completely sold.

Data collected by the University of Illinois, the State of Illinois Water Survey, the State Geological Survey, the Water Company and other competent observers indicated a decrease of available underground water supply, and confirmed the belief that eventually it would be depleted, requiring the tremendous expense of developing a surface supply.

The water company well No. 39 was drilled in 1926. At that time the static water level was at approximately 619 ft. U.S.G.S. Datum; in late

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A paper presented on June 24, 1942, at the Chicago Conference by Frank C. Amsbary Jr., Vice-Pres., Illinois Water Service Co. Champaign-Urbana, Ill.

1940 this level had dropped to approximately 590 ft. U.S.G.S., a total drop of 29 ft. It is interesting to note that the greatest rate of recession has been since 1937, which is coincident with the rapid development of air-conditioning in the community served.[1]

The tremendous recession since 1937 should be viewed with alarm for "... in connection with the study (in) other areas (it is probable) that the recession becomes more rapid as the end of the deposit is reached."[2]

The University of Illinois records[3] show a recession comparable to that of well No. 39, the drop for the same period of time being only 4 ft. less.

This recession might be interpreted as only the result of increased draft placed on the aquifer. It is more probable, however, that it is the combination of this fact and failure of nature to recharge the gravel deposits. There is no evidence of recharging of the aquifer from rain or melting snow,[4] and if such recharging is taking place it is at a considerably slower rate than the rate of withdrawal.[5]

Impetus for Conservation

It was fortunate that the impetus for conservation was furnished during a flurry of agitation for municipal ownership. The two city administrations appointed a joint committee to investigate thoroughly the advisability of such a purchase. The subcommittee investigating the engineering aspects of the proposal reported that the "situation (relative to the) source of supply was becoming critical, and that the maintenance of an adequate water supply in this community, as well as a large portion of the Midwest, deserved serious consideration."

This report was published in all local newspapers in May 1941 and furnished the bridgehead for the company in the launching of a conservation movement. In addition to the impetus given by this report, the State Legislature added momentum by the appropriation of over $100,000 for a special study of underground water supplies in the state of Illinois.

The public was becoming more receptive, so that by December the management felt the moment had arrived to make specific recommendations. Shortly after the first of the year, assurance of co-operation had been received from all interests concerned and a petition was filed with the Illinois Commerce Commission requesting the right to restrict the use of water for air-conditioning and other refrigeration.

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[1] F. C. AMSBARY JR. Re: testimony I.C.C. Case 30344. Case presented by J. G. THOMAS of Dobbins, Dobbins & Thomas, Champaign, Ill.

[2] J. J. DOLAND. Re: testimony I.C.C. Case 30344.

[3] H. L. WHITE. Re: testimony I.C.C. Case 30344.

[4] W. D. GERBER. Re: testimony I.C.C. Case 30344.

[5] L. E. WORKMAN. Re.: testimony I.C.C. Case 30344.

Air-Conditioning Water Consumption Survey

The decision to curtail use of water for this class of service was arrived at after a careful study of pumping records which disclosed that the character of the load had changed over the past four to five years. In the summer, instead of nominal pumping rates throughout the day with peak sprinkling rates in the evening, an almost constant rate was maintained throughout the day and evening, the evening peaks for sprinkling coming on when the air-conditioning was shut off.

This study further disclosed that approximately 22 per cent of the day's pumpage was going to air-conditioning alone. One of the most convincing exhibits supporting this figure was the comparison of pumpage of August 11, 1941 and August 13, 1941.

August 11, 1941 was an exceptionally hot day, the maximum temperature being 99°F. and the minimum, 73°F. It appeared reasonable to assume that air-conditioning apparatus was operating at maximum capacity. On the second date, August 13, 1941, the temperature was moderate, the maximum being 75°F. and the minimum, 51°F. It is assumed that if any air-conditioning apparatus was used on that day, it would be operating at a minimum capacity. On August 11, total pumpage was 4,435,000 gal. and on August 13, 3,490,000 gal., a differential of 945,000 gal., indicating an increase in total pumpage of approximately 22 per cent, chargeable to use in air-conditioning. In drawing this conclusion, the difference in elevation of water in a 1-mil.gal. standpipe was compensated for and sprinkling demands were given consideration.

An independent study was made by a local air-conditioning expert,[6] who estimated that a total air-conditioning load of approximately 1,000 tons or equivalent tons were in use in this community. He then assumed an average rate of 2 gpm. of water per ton of refrigeration for an eight-hour day, and arrived at the figure of 960,000 gal. of water used. This checks within 15,000 gal. of the figure disclosed by the study of pumping records.

These are the consumption figures for the summer months of 1941, with air-conditioning industry in its infancy. Under normal economic conditions it is probable that demands for this class of service would increase many-fold in the coming ten years.[6] Unless some steps are taken to enforce economy, the figure of 22 per cent of total pumpage could easily become many times greater.

These data indicated a use of water in such quantities that further study of possible conservation to this class of consumer was felt to be a *must*, for no other class could be curtailed without restricting an essential service.

The next question, then, was: How is this consumption to be reduced without making it necessary to eliminate air-conditioning in the com-

[6] ROBERT BISHOP. Re: testimony I.C.C. Case 30344.

munity? The answer seemed to be that, through the use of mechanical refrigeration equipped with evaporative condensers, cooling towers or comparable apparatus, this end could be accomplished.

The water as produced from the wells maintains a temperature of approximately 54°F.[1] With a water of this temperature it is "cheaper to take the water, use it and throw it away than it is to install recirculation equipment"[6] on air-conditioning apparatus and other refrigeration. Knowing this, all consumers using cooling apparatus run the water through the coils or compressor direct to waste.

Further study disclosed that:

"1. Air-conditioning installations, in which water direct from the city mains at a temperature of 58°F. is used as a direct cooling medium in extended surface coils, will require 3 to 8 gpm. of water per equivalent ton of refrigeration.

"2. If this type were converted into mechanical condensing units with conventional shell and tube condensers, or pipe condensers, and using water from the city supply mains, it would save 73 per cent of the water previously used.

"3. If evaporative condensers were added to the mechanical condenser units, as described under Item 2, a further saving of water of 22 per cent would be effected, or a total saving of 95 per cent of the water used in the first installation described above (Item 1).

"4. From the latest information available it appear[ed] that above 60 per cent of the total [air-conditioning] installations in use [in the United States] are either air-cooled or use cooling towers [or evaporative condensers, etc.], thus, practically speaking, eliminating any demands for city water."[7]

Proposed Prohibitive Rate Plan

The only answer to this problem seemed to be to evolve some method of making the cost of water prohibitive for air-conditioning and refrigeration apparatus not equipped with some acceptable water salvaging device. With this thought in mind the following rule and regulation was filed with the Illinois Commerce Commission with an appropriate petition requesting that body's favorable consideration:

"The schedule of rates for water service, Ill.C.C. No. 4, Sheet No. 1, issued September 12, 1934, effective October 1, 1934, applicable to the brackets at a rate of 10¢ per 100 cu.ft. and at a rate of 6¢ per 100 cu.ft., shall not apply where water is used in water-cooled condensers or where water directly from the mains is used as a direct cooling medium in air washers of any type whereby the air to be conditioned comes into direct contact with sprays or wet surfaces, or where water is used as the direct

[7] MAURICE C. FAHNESTOCK. Re: testimony I.C.C. Case 30344.

or indirect cooling medium in coils, all for the purpose of changing the dry bulb temperature or the humidity content of the air, whether used in conjunction with summer comfort air-conditioning or other refrigeration; provided, however, that nothing herein contained shall eliminate the use of water at the rate of 10¢ per 100 cu.ft. for the excess used over 18,000 cu.ft. and 6¢ per 100 cu.ft. for the excess used over 30,000 cu.ft. per quarter where the water is used for make-up water in such auxiliary equipment as cooling towers, spray ponds and evaporative condensers, or where water is used in conjunction with summer comfort air-conditioning or other refrigeration where all of the same water is subsequently used for any other purpose not hereinabove mentioned."

It should be noted that this interpretation of the rate schedule is so worded that if waste of water is eliminated, the consumer is entitled to the published rates, as follows, with no exceptions:

First 9,000 cu.ft. per quarter	25¢ per 100 cu.ft.
Next 9,000 cu.ft. per quarter	18¢ per 100 cu.ft.
Next 12,000 cu.ft. per quarter	10¢ per 100 cu.ft.
Over 30,000 cu.ft. per quarter	6¢ per 100 cu.ft.

The last two steps are the rates to be denied any consumer who can not comply with the stipulations of this rule.

TABLE 1

Comparison of Costs Under Present and Proposed Rates

CONSUMER EXHIBIT NO.	1941 WATER CONSUMPTION, GAL.	COST—PRESENT RATE	COST—PROPOSED RATE	AMOUNT OF INCREASE	PERCENTAGE INCREASE
1	7,552,500	$735.00	$1,837.80	$1,102.80	150.0
2	4,869,067	521.34	1,196.82	675.48	129.6
3	1,144,500	817.50	2,085.30	1,267.80	155.0
4	2,808,000	339.36	699.12	359.76	106.0
5	2,864,250	359.94	721.62	352.68	98.0

Table 1 graphically shows the effect that this application of the rate schedule would have on the cost of water to just a few of the consumers who operate air-conditioning and refrigeration equipment.[8]

With the installation of water salvaging equipment on the cooling systems of any of the consumers listed above, the cost of water (Column 3) would be reduced sufficiently to cover the fixed charges and operating cost of the required additional equipment. In other words, "the operating cost over all would be practically the same"[6] before and after complying with the water company's proposed regulation.

[8] Protestants exhibits. Re: testimony I.C.C. Case 30344.

Action of the Commission

The petition was filed January 7, 1942, a hearing held by the Illinois Commerce Commission on February 3, and an order issued February 11, granting the company's request, with the following provision: "Unless an extension of time is granted by [the] Commission . . . [if] any customer or customers of the Illinois Water Service Company [requests] an extension of time . . . in event that it may become apparent that said customer or customers by June 1, 1942, after diligent efforts, will be unable to equip air-conditioning equipment in their premises with apparatus for the conservation of water as contemplated by [the] order, and are prepared to make appropriate showings by affidavit or otherwise to that effect."[9] This provision was prompted by the scarcity of materials due to the existing national emergency.

As pointed out at the beginning of this paper, the problem in the Champaign-Urbana area basically is water supply. Whether it is water supply or a problem of approaching the limits of capacity of the purification plant, high-duty pumpage or distribution system, such a rule and regulation will add years to the present facilities, thereby postponing the large capital expenditures necessary to augment plant and equipment to handle this eight-week demand.

Discussion by *J. J. Doland*.* The author has presented a clear cut, factual statement of the inception and accomplishment of a most unique instrument designed to prevent unnecessary waste of underground water resources. Unfortunately too few people realize the gravity of the situation which must be faced with respect to ground water depletion. Technological advances, particularly in the fields of power production and air cooling have placed a tremendous load upon ground water resources. The former concept that "if you need more water dig another well" is rapidly becoming outmoded as a result of advancing mechanical processes.

Except in isolated localities, where far-seeing individuals have promoted conservation measures, little is really known regarding the actual effects of excessive draft on ground water sources.

The present economy of many communities is dependent upon ground water resources. Rude awakenings have already been experienced and others will be just around the corner as the impact of the effect of war industries becomes increasingly imposed upon ground water supplies.

The method described by the author is but one of the effective means of preventing inexcusable waste. By itself, however, it cannot be fully

[9] Formal order of the I.C.C. Re: Case 30344.

* Professor of Civil Engineering, University of Illinois, Urbana, Ill.

effective unless it is supported by local government to prevent or control wasteful use from private wells which tap the same aquifer. Such controls may be exercised through legislation governing well permits, restrictions on type of use, or denying the right of sewers for the disposal of water which is wilfully or unnecessarily wasted.

The "rationing" of ground water through legislative and utility commission controls is very strongly in the picture of the near future. In many areas, already affected by extreme overdrafts, studies and investigations have been started to determine data on supply and demand and the remedial measures which may be applied. Artificial recharge is possible in some instances but the difficulties attendant upon this means are many. The natural approach to a solution lies in the balancing of supply and demand. Data on demand are relatively simple to obtain but the determination of supply usually involves a well planned and technically sound investigation program. In many cases it will be found that municipalities are conducting a mining operation and unfortunately for some, the "veins" are just about worked out.

It is the duty of every water works man, concerned with ground water supplies, to investigate his situation if he has not already done so. In several instances of near failure the real danger was not realized until the situation became critical. Available data on the progressive rate of water level recession, rate of draft for private and municipal uses, character of industrial and commercial use and probable source and rate of replenishment are essential to the formulation of equitable control measures. The more data of this character which are available when the need for control arises the simpler the approach to a solution of the problem.

The author has demonstrated how the availability of such data has led to the exercise of one form of control. It is certain that without it the petition of the Illinois Water Service Company to the Illinois Commerce Commission would have failed.

Through the medium of the National Resources Planning Board the order of the Illinois Commerce Commission has been given nationwide publicity. The comments which are now being received indicate that it is considered a forward step as a control measure.

As a result of his foresight as manager of a utility, the author has performed, by the emphasis he has placed on the need for conservation of ground water, a signal service to the people of the community he serves and incidentally to the nation.

Water Waste Prevention and Correction in Pittsburgh

By Homer E. Beckwith

IN 1941 the daily average output of water in Pittsburgh was the lowest since 1909, although the revenues of the water department reached an all-time high. The fact that this decrease in demand occurred at just the time that the war effort was reaching its peak is most fortunate. It makes Pittsburgh almost unique among American cities engaged in war work, in that it has no present water supply problem. All the original margin of safety built into the filter plant, which was put into operation about 1909, has been restored. The reservoirs and transmission mains built in recent years probably give the Pittsburgh water system today the highest ratio of capacity to demand which it has enjoyed in the past generation. As a result, it can look forward confidently to the job of supplying the demands of the war effort without any strain upon its facilities.

That this is so is no accident, but the result of a program of water conservation beginning in 1929 with the initiation of a water waste survey.* Not all the savings are directly the result of the survey, but most of them stemmed from it, as results of conditions thereby disclosed.

Unfortunately for financial reasons, brought about by the recent depression, it was impossible to complete the survey of the city in one continuous operation. The survey started late in 1929, was discontinued in 1932 when about two-thirds of the main mileage had been covered. It was resumed in 1938 as a W.P.A. project and completed in 1939. In view of the length of time which had elapsed since the original work, it was decided to resurvey the area covered between 1929 and 1932. This resurvey was completed early in 1942. As a result, all waste which had returned in the intervening ten years was located and eliminated and a continuous survey of the system made.

A paper presented on September 18, 1942, at the Western Pennsylvania Section Meeting, Pittsburgh, by Homer E. Beckwith, Dist. Mgr., The Pitometer Co., Pittsburgh.

* This survey was made by The Pitometer Co., with whom the author is associated.

Results of the Original Survey

The results of the work are shown graphically by the accompanying pumpage chart (Fig. 1) for the years 1928–41. To be sure, the depression influenced some of the middle years, but the years 1928–29 on the one end and 1940–41 on the other were years of considerable activity in Pittsburgh industries. As a matter of fact, present Pittsburgh employment is at an all-time peak and the chart would tend to minimize rather than to exaggerate the savings effected. It is interesting to note that the important reductions in pumpage took place from 1929 to 1932 and from 1939 to 1941, that is, in the years during which the survey was in progress.

The water waste survey was made by a system of direct and indirect measurements by means of which the distribution of water throughout

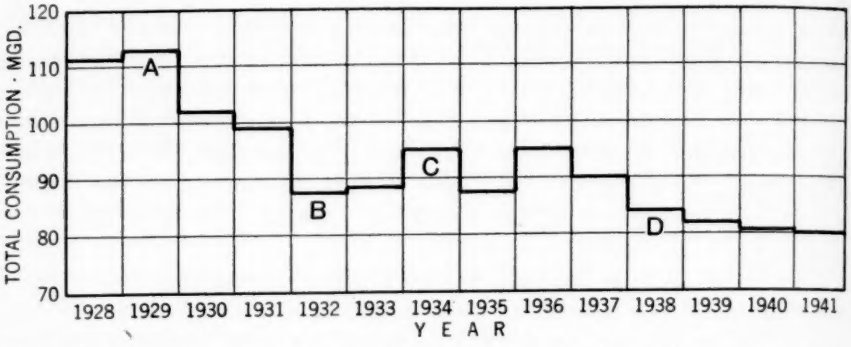

FIG. 1. Pittsburgh Pumpage Chart, 1928–41; showing points of—*A*, Start of Survey; *B*, Discontinuance of Survey; *C*, Leaks in Monongahela and Allegheny River Lines; and *D*, Resumption of Survey

the system was determined. The distribution of the night flow was measured almost block by block. As a result, the location and amount of all sources of waste was determined. The waste was classified in five different categories.

The savings, in gallons per day, resulting from the first complete coverage of the city—1929–32 plus 1938–39—listed according to this classification, were as follows:

Underground Leakage	9,989,000
House Waste	11,972,000
Unauthorized Use	1,640,000
Under-registration of Industrial Meters	988,000
Leakage Between Pressure Areas	435,000
Total	25,024,000

The one instance of unauthorized use discovered during the survey did not result in increased revenue. Soon after discovery, the use stopped, so that the net result was a reduction in pumpage.

About 80 per cent of the valves were operated and shut-outs for practically all the mains were tested in connection with measurements for leakage. In other words, errors in the city's maps of the distribution system were discovered and defective valves were located and turned over to the maintenance department for repairs. In the event of future necessity for shutting areas out of water quickly, this feature of the survey may prove to be invaluable.

Results of the Resurvey

The resurvey of 1939–42 covered the area surveyed in 1929–32. The savings effected by this resurvey must be regarded as the re-establishment of the original savings and not as additional ones. Nonetheless, the results

TABLE 1

Comparative Savings in Gallons Per Day for Original Survey and Resurvey

	Original Survey	No. of Leaks	Resurvey	No. of Leaks
Underground Leakage (exclusive of river lines)	5,455,000	375	4,870,000	362
House Waste	11,089,000	8,518	3,168,000	2,966
Unauthorized Use	1,640,000	1	None	None
Under-registration of Meters	766,000	—	125,000	—
Leakage Between Pressure Areas	435,000	—	None	—

of this work were both profitable and interesting. Of especial interest is a comparison of the nature and amount of waste discovered by the two surveys, given in Table 1. The area affected comprises about two-thirds of the system. Losses from river lines are not included.

It will be seen that about 90 per cent of the underground leakage had returned after ten years. However, only about 30 per cent of the house waste had returned. This was due to two developments. The installation of a large number of domestic meters had so increased the number of metered services that in 1941 about 66 per cent of the total number of services were metered as compared with only 40 per cent in 1928. Moreover, the large amount of house waste discovered by the original survey resulted in a more aggressive program of house inspections by the department, carried out under the direction of the Chairman of the Board of Water Commissioners. A campaign for the elimination of as much free water as possible and for the metering of the part that could not be eliminated has also been vigorously pressed.

It will be noted that no unauthorized use was found during the resurvey. As pointed out previously one instance of such use was found during the original survey—an industrial plant taking an average of 1,640,000 gpd. which it had apparently been taking for years. This situation was inherited through annexation and the use stopped soon after discovery. It is believed that the use had continued for a quarter of a century prior to its discovery.

Under-registration of industrial meters was much less when the second survey was made than it had been ten years before. Inter-area leakage had been eliminated.

Benefits of the Conservation Program

The net result of the survey and other steps taken for the conservation of water was that the average daily consumption was 80.6 mgd. in 1941 as compared with 111.2 mgd. in 1928, which was the last full year before the survey started. This represents a reduction of 30.6 mgd. About 25.0 mgd. of this can be credited to the survey. The saving of the remaining 5.6 mgd., plus the amount required to meet the increased demand of the greater population can be credited to the other steps taken.

Placing a production value of only $20 per mil.gal. on the leakage and house waste and its sale value of $140 per mil.gal. on the under-registration of industrial meters, the savings resulting from the survey would pay the cost of the work within a few months.

This is not all the benefit derived by the city, however. The reduction in pumpage indicates that a third of a century of city growth has been absorbed and all the excess capacity built into the plant thirty-three years ago has been restored and is now available to meet the demands of the war effort.

The return, after ten years, of 90 per cent of the underground leakage indicates the necessity of taking steps for its permanent control. This is the purpose of a contemplated plan to make continuous surveys of the city distribution system. One section will be surveyed each year and the sections will be of sufficient size to insure coverage of the city often enough to prevent the return of any appreciable amount of leakage. This system has worked well in practice in other cities and it is expected that it will work well in Pittsburgh.

James Kennon became Managing Engineer of the Bureau of Water about the time the survey started and it is in large measure a result of his faith in the value of the work that the project was kept going through the difficult years of the depression. George McK. Beleau is the Chairman of the Board of Water Commissioners responsible for the success of the house waste prevention program.

Survey of Billing and Collection Practices of Cities of 100,000–200,000 Population

By George F. Hughes

WATER works men who are handling the collection of water charges should at the present time be on the alert to improve their methods so that situations which occurred during the depression period following the World War do not reoccur. It will be recalled that at that time many departments were actually pressed for funds for maintenance and operation purposes because collection methods or laws were not set up in a manner to enable them to press collections. It is understood of course, that some of these conditions were unavoidable because of prevailing laws that had already outlived their usefulness and should have been changed so that improved and modern methods could be used. Therefore, it is believed that a statement of the several collection methods used by cities in the same population group will be of particular interest at this time.

From the data furnished by 37 cities in the 100,000–200,000 group, it is found that water departments are using a number of different types of billing machines, all of which are apparently giving satisfaction in all instances. Further is it observed that a large proportion of the water departments of this group do a splendid and efficient job of collecting accounts.

In preparing the information collected, some reports may have been interpreted incorrectly but it is believed that sufficient data are presented to explain intelligently the methods employed by the several cities.

Of these cities, 21 stagger their quarterly billing monthly; 7 cities stagger their monthly billing every two or three days, or daily; and 9 bill only once a month. No doubt, a very great advantage is accomplished by staggering the billing of accounts, as evidenced by the number of cities using this method. The cities operating under the staggered system are undoubtedly using their meter readers and clerical force to better advantage, which at the present time, when labor is so difficult to secure, is of vital importance.

A paper presented on June 25, 1942, at the Chicago Conference by George F. Hughes, Mgr., Board of Water Comrs., City & County of Denver, Denver, Colo.

TABLE 1

Billing Methods of 37 Cities in the 100,000–200,000 Population Group

CITY	QUARTERLY BILLING STAGGERED MONTHLY	MONTHLY BILLING STAGGERED DAILY	MONTHLY BILLING	QUARTERLY BILLING	LARGE BILLS MONTHLY SMALL BILLS QUARTERLY	BILLING SEMI-ANNUALLY	SERVICES METERED	SERVICES SCHEDULED & METERED
Albany, N.Y.			X*			X†		X
Bridgeport, Conn.	X			X				X
Cambridge, Mass.	X			X			X	
Canton, Ohio	X			X			X	
Duluth, Minn.	X			X			X	
Erie, Pa.					X			X
Evansville, Ind.				X			X	
Fall River, Mass.	X						X	
Fort Wayne, Ind.		X	X				X	
Fort Worth, Tex.	X		X				X	
Flint, Mich.					X		X	
Gary, Ind.		X	X				X	
Hartford, Conn.	X					X		
Jacksonville, Fla.					X		X	
Kansas City, Kan.		X	X				X	
Knoxville, Tenn.		X	X				X	
Long Beach, Calif.		X	X				X	
Lowell, Mass.	X			X			X	
Miami, Fla.	X				X		X	
Nashville, Tenn.					X		X	
New Bedford, Mass.	X			X			X	
New Haven, Conn.	X				X			X
Norfolk, Va.		X		X			X	
Patterson, N.J.	X				X		X	
Richmond, Va.					X		X	
Scranton, Pa.	X				X		X	
Somerville, Mass.	X			X			X	
South Bend, Ind.					X		X	
Spokane, Wash.	X				X		X	
Springfield, Mass.	X			X			X	

* Meter rate.

† Flat rate.

TABLE 1—*Concluded*

Tacoma, Wash.	X		X				X	
Tampa, Fla.		X	X				X	
Tulsa, Okla.	X		X				X	
Utica, N.Y.	X				X		X	
Wilmington, Del.	X			X			X	
Worcester, Mass.						X	X	
Yonkers, N.Y.	X				X		X	
Totals	21	7	10	12	13	3	32	4

The record of billing methods (Table 1) indicates that the system of billing large accounts monthly and small accounts quarterly is the most economical and efficient method.

Collection Practices

It was found that meters are used in 32 of the cities and that the other five are partially metered. A few of the departments require deposits to insure collection of accounts:

Long Beach, Calif., requires a deposit of $2.50 per month from small consumers, while large consumers must place on deposit an amount two and one-half times the average monthly bill.

Miami, Fla., requests an advance payment of $3.75.

Jacksonville, Fla., requires a deposit of an amount equal to the minimum bill.

Nashville, Tenn., estimates the amount of the deposit according to the number of tenants on the service, $1.50 per tenant. Large account deposits are regulated through experience.

Norfolk, Va., requires $2.50 advance payment.

New Bedford, Mass., asks a deposit of $5.00.

Flint, Mich., and *Tulsa, Okla.*, require a minimum deposit of $5.00.

Wilmington, Del., and *Albany, N.Y.*, request a deposit of the minimum rate.

This record shows that only ten cities, slightly over 25 per cent of those reporting, use the deposit system of protecting the collection of water rents. No doubt the majority believe this method of handling accounts too cumbersome and expensive, even though it is very effective.

Methods and rules governing the collection of delinquent accounts are of great variety, as will be noted from the detailed statement, Table 2. It is very evident that the cities which keep a close check on the collection of accounts are operating efficiently, partly because they show no partiality in granting extensions in time.

TABLE 2

Methods Used in Collecting Delinquent Accounts in 37 Cities in the 100,000–200,000 Population Group

	1ST DELINQUENT NOTICE—DAYS AFTER DUE DATE	2ND NOTICE—DAYS AFTER 1ST NOTICE	3RD NOTICE—DAYS AFTER 2ND NOTICE	METHOD
Albany, N.Y.	—	—	—	Discount on meter bills of 3% if paid 10 days, 2% in next 6 days; bills not paid within six months 5% penalty added and lien law applied on schedule bills
Bridgeport, Conn.	—	—	—	First notice sent reasonable time; second notice reasonable time; then turn-off
Cambridge, Mass.	—	—	—	Allow 9 months to year to pay; then apply lien law
Canton, Ohio	10	5	—	Discount 10% first 10 days; after 5-day notice, service discontinued
Duluth, Minn.	—	—	—	No notice except rider put on original bill with notation that each time collector calls a charge of 50¢ added and $1 if turned off
Erie, Pa.	30*			
	10†	15	—	Then collector, followed by turn-off
Evansville, Ind.	None	—	—	New method: Original bill states no notices or collectors are sent out and that water will be absolutely shut off at a certain date; Big improvement over former lenient method
Fall River, Mass.	30	—	—	Penalty 10% after 10 days, but not to exceed $1
Fort Wayne, Ind.	20	5	—	Collector calls after second notice and, if unable to collect, water service discontinued
Fort Worth, Tex.	10	—	—	Service discontinued after 10 days; no exceptions
Flint, Mich.	—	—	—	Bills sent out with 10% discount if paid within specified time; otherwise gross amount collected; if service discontinued, $1 charge.
Gary, Ind.	15	3	5	10% discount if paid within 15 days; service discontinued after 5-day notice
Hartford, Conn.	30	30	—	5% penalty 50 days after due date; then 1% added the first of each month; if service turned off $2 charge

TABLE 2—*Continued*

	1ST DELINQUENT NOTICE—DAYS AFTER DUE DATE	2ND NOTICE—DAYS AFTER 1ST NOTICE	3RD NOTICE—DAYS AFTER 2ND NOTICE	METHOD
Jacksonville, Fla.	30	3	—	Then shut off; only 0.0018% charged off as uncollectible
Kansas City, Kan.	10	5	—	Penalty of 5% added after 10 days; then after 5 days, collect or turn off
Knoxville, Tenn.	10	—	—	Penalty 10 days after due date: 25¢ for minimum bills of 500 cu.ft. 30¢ for next 3,500 cu.ft. 10¢ for 4,100 cu.ft. or more
Long Beach, Calif.	15	—	—	Only one notice, then collector and finally shut off
Lowell, Mass.	90	—	—	Lien law applied and collector for old account
Miami, Fla.	2	5	—	After notices sent, collector calls and either collects or shut-off notice in 24 hr.
Nashville, Tenn.	15	3	5	After third notice, 50¢ service charge added. Accounts billed at two rates: net and gross, gross being 2¢ per 100 cu.ft. more than net. If bills not paid within 15 days, gross rate automatically becomes effective
New Bedford, Mass.	30	15	—	If not paid after first notice, 50¢ demand charge added; after 15-day notice time expires, service turned off
New Haven, Conn.	30† 40*	—	—	Schedule bills or 33⅓% of bills collected six months in advance
Norfolk, Va.	10	—	—	First notice states if bill not paid in two days service shut off and $1 charge made
Patterson, N.J.	10	—	—	Then collector
Richmond, Va.	15	5	—	After 5-day notice, collector calls; collects or discontinues service
Scranton, Pa.	20	4	10	After 4-day notice 5% penalty added; turn-off after 10-day notice
Somerville, Mass.	10	30	—	If not paid within year, lien law applied
South Bend, Ind.	15	7	—	10% penalty after 15 days on bills of $3 or less and 3% on bills over $3; after 7-day notice, collector calls
Spokane, Wash.	20	15	—	Turn-off after 15-day notice; $1 charge made

TABLE 2—*Concluded*

	1ST DELINQUENT NOTICE—DAYS AFTER DUE DATE	2ND NOTICE—DAYS AFTER 1ST NOTICE	3RD NOTICE—DAYS AFTER 2ND NOTICE	METHOD
Springfield, Mass.	20	20	15	After expiration of 40 days collector calls and, if not paid, leaves bill and secures receipt; after the 15-day notice service turned off and charge of $2 assessed
Tacoma, Wash.	10	60	—	After 60-day notice, turn-off; $1 charge
Tampa, Fla.	50	30	—	10% discount if paid within 10 days (80% pay); after 50-day notice, collector calls; after 10-day notice, turn-off
Tulsa, Okla.	10	—	—	After 10 days, 5% penalty
Utica, N.Y.	10	15	30	2% discount if paid in 10 days; after 30-day notice, collect or turn-off; $2 added
Wilmington, Del.	30	60	—	Discount of 5% in first 30 days; after 60 days, service discontinued
Worcester, Mass.	40	60	—	Second notice stipulates 30 days; thereafter water service shut off or lien law applied
Yonkers, N.Y.	30	—	—	After 10 days, shut-off

* Quarterly bill.
† Monthly bill.

Also evident from the detail of Table 2 is the fact that the application of the lien law is in general use as a method of collection in Massachusetts, four of the five cities applying the law being located in that state. There is no question but that cities which can apply a lien law have many of their delinquent account problems solved.

In the author's experience in the Denver Water Department, he has found that many consumers—in fact, about 25 per cent—habitually delay paying their bills until delinquent notices have been issued. This practice is patently unfair to the 75 per cent who pay promptly.

No conclusions have been drawn from the data presented in this paper. It is hoped, however, that the information given will be of assistance to water works men in suggesting improvements of inadequate methods now employed.

How the Examiner Looks at the Water Works

By Frank B. Thomas

IF THIS subject were to be presented as a mere question, the answer would be: "The examiner looks at the water works as a business proposition." But even this answer might call for some elaboration upon the elements of that business, of which there are at least three: (1) cost of production and distribution of the water supply; (2) revenue collection; and (3) record keeping and reporting.

Most water works men agree with the Supreme Court of Ohio that a municipality operates its water works in a proprietary capacity, rather than with the Bituminous Coal Authority that it is a purely public function and therefore exempt from the excise tax of one cent per ton of coal. It matters little for the purpose of this discussion what side one takes; the fact still remains that costs must be known before a selling price for a commodity can be intelligently fixed.

Cost of Production

A city may produce as well as distribute the water supply to its citizens or it may purchase its water supply at a master meter and distribute it from that point. These conditions suggest that the former is a manufacturer or producer as well as a retailer and that such city should have a clear knowledge of its cost of production.

It is common knowledge that cost keeping involves two elements—units and price. It follows that a producer of water, or the examiner, would wish to know the number of cubic feet of water pumped as well as the cost of bringing it to the point of beginning distribution to consumers. If water is pumped into reservoirs or other storage to be distributed at a later date, accurate inventories of water in storage should be maintained so that definite knowledge of the quantity of water actually delivered to the distribution system may be determined.

A paper presented on May 14, 1942, at the Ohio Section Meeting, Toledo, Ohio, by Frank B. Thomas, Deputy Supervisor, Bureau of Inspection and Supervision of Public Offices, Columbus, Ohio.

Up to this point the municipality or water works must be considered a manufacturer or producer and as such it would, with this knowledge at hand, be capable of fixing a wholesale selling price. If unit costs up to that point are not known, then any price set would seem to be based upon guesswork.

It must be admitted of course that such unit costs involve more than the mere cost of pumping the water. Depreciation on the pumping and storage plant, possibly depletion of the water supply, maintenance of such facilities and such portion of the overhead and managerial expense as can properly be allocated to water supply production must all be considered.

All these costs can be ascertained upon the unit basis, the overhead expense being adjusted from time to time as dictated by experience. The examiner would be extremely interested in a study of such cost records if they were available, as the producing city would, from that point, be in the same position as the city that purchases its water supply for distribution only.

Cost of Distribution

One element of the cost of distributing water that seems to be overlooked, or at least not given proper consideration by the management of water works systems, is the loss of water through distribution. In other words, that quantity of water pumped or taken from storage in excess of the quantity sold to consumers. Certainly the value of this lost water constitutes a cost of distribution. It would seem only proper that water works administrators arrive at an irreducible minimum water distribution loss based upon pipeline mileage and size of pipe, or some other unit of measurement. Thereafter they should become greatly concerned when the loss is shown to be in excess of such irreducible minimum.

Depreciation of pipe lines, if constructed of cast-iron pipe and free from electrolysis, will be very low in comparison to that of the pumping plant. The meters, however, wear out faster and there is a sizeable maintenance cost of lines and meters. Also, a portion of the general overhead expense may properly be allocated to cost of distribution, and these costs also can be ascertained with a better than fair degree of accuracy.

Revenue Collection Records

In the author's estimation, revenue collection begins with the meter reader. His folio books should be adequate for the purpose and so well constructed as to stand hard wear and even abuse. Also, the meters should be read by actual observation and not from a comfortable chair in a pool room or back room of a saloon. The meter books should be arranged by streets and zones, since the addressograph system is largely used for billing consumers.

The author favors the three district plan for billing consumers, i.e., one-third of the consumers are billed for a three months' period in one calendar month, another third during the next calendar month and the remaining third in the third month. Each one of the three districts should be subdivided into a number of zones as above indicated, so that it is possible to stagger the billing and collecting for a single district within the calendar month. Under this method the revenue receipts are constant and become available for meeting the operating costs month by month.

Where possible, there should be a clear separation of the cashier's, or collection, department from the billing and record keeping department. Then, if the meter readers' books are fully and accurately kept to show the cubic feet consumed and amounts to be billed, the bookkeeping of consumers' accounts will not be so important. Thus, the old form of consumers' ledger in longhand, the machine bookkeeping ledger or even the so-called stub system, if safeguarded by audit run-off sheets and ample controls, may serve as a record of earnings from consumers.

Regardless of the form of consumers' ledger, the examiner will expect to find an adequate miscellaneous ledger to show the charges and collections from the sources of water service connections, sales of water for construction purposes, meter repairs, on-and-off charges, sale of junk, etc., and he will note the internal checks and balances upon the source of such miscellaneous income. Most of the actual shortages in water works income accounts as found by state examiners are the result of, or at least start through, a manipulation of the miscellaneous, and not the consumers', accounts; therefore, adequate records of taps and service connections, that form the basis for consumers' accounts, should be maintained at all times, along with meter settings and the on-and-off records. The use of the turn-off key should be the responsibility of one man, but no curbstone or other collection of accounts should be made by that man, or by anyone other than the official cashier or collecting agent.

Records of Materials, Purchases and Supplies

It will no doubt be agreed that the true basis of cost of commodities is their consumption or use as the purchase in the first instance is merely the conversion of one asset to another. Accordingly, the ideal method of handling these purchases and their distribution is through the use of a central warehouse or stores account. It will be observed that if all such purchases were charged to stores and issued from stores upon requisitions to the various cost accounts or consuming departments for immediate use, the monthly or periodic inventories after checking with the continuous inventory of such materials and supplies would represent an asset rather than expense. This method of recording such purchases is entirely practicable in the larger cities.

General Financial Records

In most of Ohio's municipalities the chief fiscal officer—city auditor, director of finance or village clerk—acts as the general bookkeeper for all departments including the water works, the water department confining itself to keeping the detailed accounts of revenue and expenditures along with the budget or appropriations and such cost accounts of line extensions and other improvements as the director or superintendent may deem necessary. Very few water departments maintain inventories of materials and supplies.

In only a few cases do such general bookkeepers record the aggregate of charges against water consumers and credits to their accounts, to control adequately the detail of accounts receivable or delinquent accounts. The water department in general has little knowledge of its bond and interest indebtedness other than the debt service vouchers its officers are required to approve from time to time, to transfer the water funds to those in charge of bond retirement. The net result is that the water officials have little or no knowledge of their financial status until the state examiner's operating statement shows them, generally, that, so far as is ascertainable from all available records, they are losing money.

Such water works administrators do not concern themselves seriously with such "trifles" as depreciation, inventories of supplies and materials, value of free water service, loss in taxes to the city upon the plant valuations, etc., yet all of these constitute revenues or expenses, if any comparison of their operations is to be made with those of a privately operated plant. Surely there is a need for general ledger accounting in the water works department; and this applies to municipally owned electric and other utility plants as well as water works.

Municipally owned utilities have not, in the past, been compelled to determine costs closely or to be concerned with profits or losses, or to set aside cash reserves for depreciation, etc., because of the tremendous borrowing power of municipal corporations. When plants have worn out, they have simply appealed to the council to issue bonds to build new ones. Water lines have been extended into sparsely populated districts for reasons of political expediency, without regard to whether the income from such lines would amount to 1 per cent of the investment or nothing at all, so long as the money lasted. Now, times are changing, if they have not already changed.

Similarly, in the past, such administrators did not concern themselves with the alarming increase in the number and amount of delinquent consumer accounts, so long as the money in the fund lasted and paydays were constant and regular. One cashier of a water and electric plant once told of attending a meeting of a luncheon club composed of the principal busi-

ness men of his city, where he was unable to pick out a single individual in the group who did not owe money to the public utility plants. Yes, there were rules about turning off the service for non-payment of bills, but who would dare enforce those rules and expect to hold his job?

Again, it must be pointed out that times have changed. If the present administrators do not soon begin to operate their plants upon an efficient business basis, someone else will operate them that way, or there will be no plant left to operate. In other words, municipalities have been superseded as borrowers by the federal government for a much more important purpose than petty politics.

Examination of Accounts

State examiners give water works accounts, such as they are, a pretty fair going-over. They verify in detail, from their original sources, miscellaneous ledger revenue accounts such as tapping permits, meter settings and rents, meter repair orders and other original documents and observe whether or not the new taps or service connections have become productive as active consumer accounts. They verify the charges of the consumers' accounts for one or more quarters of the period covered by the examination, always keeping in mind that the correct basis of such an audit of income accounts is the verification of the charges. They do not place too much concern upon the cash book if its totals are in agreement with the cash credits in the ledgers, or upon the cashier's department that is separated from the billing and record keeping. Under such circumstances the cashier can go short only by withholding collection stubs, and if he has done this, the examiner has a sure check in the verification of the delinquent accounts.

Examiners expect to be able to prepare receipts audit statements of both the consumers' and miscellaneous accounts, and this will be easy if the accounts have been regularly balanced at the end of each quarterly or other collection period. They expect, too, that the collections as shown in the departmental records will balance with the deposits in the city treasury or will reconcile with them by consideration of any cash on hand or in transit to the treasury. They do not expect to find collections withheld from deposit in lieu of an impressed cash fund for change making or for any other purpose.

Examiners verify the voucher expenditures in detail from the original approved invoices and payrolls and check them for proper authorization, legality and accuracy. Finally, they prepare the necessary financial statements for their reports, including an operation or revenue and expense statement. In those cases where some elements of such a statement are unobtainable (such as inventories of supplies and materials) they qualify the statement with a footnote to the effect that the statement is inaccurate to that extent.

Studies on Maximum Momentary Demand

By A. P. Kuranz

THE study of maximum momentary demand for domestic uses of water was initiated as a result of a paper presented by Hal F. Smith* at the Toronto Convention in 1941. In his discussion there, Smith quoted Nathan Straus, Administrator of the U.S. Housing Authority as saying: "There is a definite lack of test data on the subject of peak load, or 'maximum momentary demand,' for which housing projects should be designed." [Later the Federal Public Housing Authority developed a chart (Fig. 1) which embodies the result of considerable study on their part. This chart is the basis upon which the water quantity allowances were set up in the Housing Utilities Standards.—*Editor.*]

Since the American Water Works Association was "put on the spot" by this statement, it led the officials to make a hurried survey of its literature, which indicated that there was considerable information available, though perhaps not in the form desired. From the experience reported, however, it is apparent that there is no lack of information. The fact that it has been disseminated under the subject of metering rather than under demand may be the reason for Straus's misapprehension.

Practically all study of maximum momentary demand has thus been carried on as a corollary to the meter surveys of the various utilities, particularly in relation to work on registration and revenues. Therefore, the following report will use the figures and data available, classifying them by the demand for water in the various types of domestic buildings rather than in their usual form as a study of meter performance. A brief summary of some of the most informative of these reports already received will give the best idea of what study has been made of the subject.

A paper presented on June 25, 1942, at the Chicago Conference by A. P. Kuranz, Supt., Water Dept., Waukesha, Wis.

* SMITH, HAL F. Special Rates for Housing Developments. Jour. A.W.W.A., **33:** 1638 (1941).

Elgin, Ill.

LaVerne Trentlage, Foreman of the Meter Division of the Water Department, estimates that nine out of ten homes, regardless of size or number of persons, will rarely exceed a maximum demand of 10 gpm. He believes that a 15-gpm. rate is more than enough for domestic users. In this statement he refers, no doubt, to a single family installation. Trentlage also made a very careful study of a sixteen-apartment building equipped with flushometer toilets. In this study the demand for the entire building was found not to exceed 35 gpm.

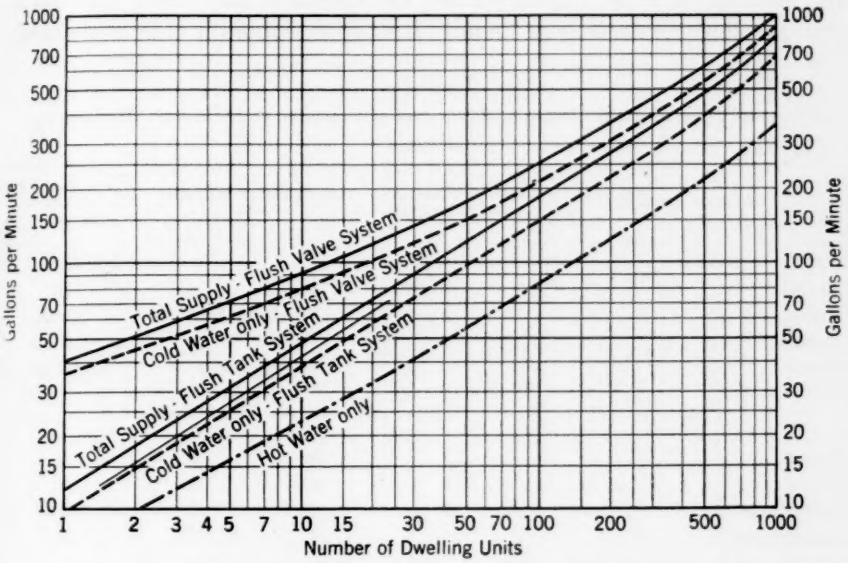

FIG. 1. Maximum Momentary Demand for Domestic Water Supply; chart originated by Paul Campbell, Federal Public Housing Authority

San Francisco

G. W. Pracy, Superintendent of the Water Department, in tests of 150 small meters* developed considerable information on maximum and minimum rates of use. Since his studies were primarily on the revenue phase of metering, however, he did not make rate-of-flow studies; but in all tests he used 15 gpm. as a maximum rate of flow when testing these small meters. From this, it can safely be assumed that that was the maximum rate, since, if demand had been greater than that, he certainly would have tested higher rates of flow.

* PRACY, GEORGE W. Testing Small Meters in San Francisco. Jour. A.W.W.A., **34**: 712 (1942).

Hartford, Conn.

An outstanding contribution to the subject has been made by the city of Hartford, under the direction of H. W. Griswold, Deputy Manager & Deputy Chief Engineer and W. A. Gentner, Office Engineer, assisted by F. S. Brainard, Distribution Engineer, all of the Water Bureau.

Maximum demand figures can easily be obtained from their studies on domestic uses. At this point, then, it might be well to point out that the domestic demand depends greatly on the type of plumbing in a home or an apartment house, e.g., whether the toilets are of the ordinary tank or of the flushometer type. Griswold and his associates made very exhaustive study on flushometer valves, finding, after several months of careful check-

TABLE 1

Effects of Type of Toilet Valve and Number of Fixtures on Maximum Momentary Demand

TYPE OF BUILDING	NO. OF FAMILIES OR APARTMENTS	TYPE OF TOILET FLUSHING VALVE		MAXIMUM DEMAND OF BUILDING
				gpm.
Home	2	Tank		10
Home	2	Flushometer		25–30
Home	4	Tank		10
Home	4	Flushometer		25–30
		NO. OF TOILETS	NO. OF FAUCETS	
Home	1	10	22	50
Home	1	10	50	23
Apartment	12	12	72	30
Apartment	21	21	26	20

ing, that the maximum rate of demand with flushometer valves in Hartford was 20 gpm. Both the 1932 and the 1940 studies clearly indicate the difference between flushometer and tank type toilets. Table 1 gives some of the results of these studies.

In analyzing these studies, Brainard commented: "The smaller systems have the greater comparative variations, such as the single house which is equipped with usual plumbing fixtures, including one or more flushometer toilets. In these cases, it is probable that the ordinary maximum demand would be a toilet flush combined with the operation of a faucet and shower bath, possibly amounting to a rate of 30 gpm. This ordinary maximum rate may possibly be increased to 50 gpm. through the simultaneous operation of an additional toilet." He presents Table 2 as a rearrangement of Griswold's tables.

Brainard continues: "It will be noted from these observations that the maximum observed rates vary greatly for similar types of buildings; also, that the maximum ordinary rate of 20 gpm. for a single house is not greatly increased by the twelve-apartment house. This is probably due to the staggered use of water by the several apartments and the generally short period of time for individual fixture operation. The operation of a flushometer toilet would probably be the greatest single demand and the probability of more than two being operated at the same instant is very remote.

TABLE 2

Maximum Drafts in Various Types of Dwellings in Hartford

TYPE OF PROPERTY—NO. OF FAMILIES	NO. FLUSHOMETER TOILETS	NO. FAUCETS	MAXIMUM DRAFT OF BUILDING
			gpm.
1	1	7	20
1	5	24	15
1	10	50	23
1	10	22	50
2	2	16	25
12	12	72	20
12	12	72	30
18	18	108	15
18	18	108	30
21	21	126	20
21	21	126	25
24	24	180	15
24	24	144	60
27	27	162	15
27	27	162	25
30	30	192	40
30	30	195	25
42	42	252	20

"The following is suggested for estimating the ordinary maximum demand [of an entire building]: 1 to 15 flushometer toilets, 20 gpm.; for each additional toilet, add 1 gpm. To this estimated toilet use, add 1 gpm. for every 10 faucets." This suggested schedule is shown in Table 3. Where tank toilets are used, he suggests that estimates be one-half the flushometer toilet use.

Roanoke, Va.

D. R. Taylor, Superintendent of the Water Department, has developed some extensive records, which indicate that only 10 per cent of the water is used at the rate of 10 gpm., the maximum demand.

Paterson, N.J.

A. T. Cook, formerly of Paterson, made some investigations years ago and found that single-family homes had a maximum use of 10 gpm., using only 0.7 per cent at that rate. For two-family homes, having no lawns, he found the maximum demand to be 5 gpm., with less than 3 per cent of the water used at this rate; with a lawn, he found the maximum demand to be 7 gpm., and less than 8 per cent of the water used at this peak demand.

TABLE 3

Estimate of Ordinary Maximum Demand for Various Dwellings

NO. OF FAMILIES OR APARTMENTS	NO. OF FLUSHOMETER TOILETS	ESTIMATED RATE FOR TOILETS	NO. OF FAUCETS	ESTIMATED RATE FOR FAUCETS	ESTIMATED MAXIMUM RATE OF BUILDING
		gpm.		*gpm.*	*gpm.*
1	1	20	6	1	21
2	2	20	12	2	22
4	4	20	24	2	22
6	6	20	36	4	24
8	8	20	38	5	25
10	10	20	60	6	26
15	15	20	80	8	28
20	20	25	120	12	37
25	25	30	150	15	45
30	30	35	180	18	53
50	50	55	300	30	85
70	70	75	420	42	117
100	100	105	600	60	165
200	200	205	1200	120	325
400	400	405	2400	240	645

Nashville, Tenn.

Robert L. Lawrence Jr., Superintendent and Chief Engineer of the Water Department, Nashville, Tenn., gives some valuable information on four major housing projects in Nashville. The services were installed so that one meter installation would supply every three or four buildings of each project. The Federal Emergency Administration had planned 3-in. services with a 3-in. meter for three or four buildings, comprising an average of sixteen apartment units. The water department permitted a 3-in. service, but installed a 2-in. meter instead. Water service for another housing project was installed similarly, except that a 2-in. service with a 2-in. meter for sixteen or less apartment units was installed. Those buildings supplied with a 2-in. meter were found to be over-metered. In giving

detailed information, he says that each apartment had a water closet, bathtub, lavatory and sink, and that the delivery of these fixtures was determined from the "Society of Heating and Ventilating Engineering Guide," figures from which gave the maximum demand of 23 gpm. The total demand was then determined by multiplying the number of apartments by this maximum demand, and this figure was cut in half to get the maximum probable demand in gallons per minute. The figure was divided in half because a study on the previous project mentioned had revealed that a 2-in. meter was much too large for a sixteen-apartment building.

On the third and fourth housing projects, the Nashville Water Department specified a 2-in. service pipe with a box built for a battery of two 1-in. meters, only one 1-in. meter being set to supply 26 apartments or less and two 1-in. meters being set to supply more than 26 apartments. The estimated maximum demand for a 26-apartment unit was 66 gpm. By installing the battery meter-setting box at each service, provision was made for the installation of another 1-in. meter if it became necessary.

TABLE 4

Comparison Between Flushometer and Tank Types at Indianapolis

NO. OF APARTMENTS	TYPE OF TOILET	SHOWERS USED	MAXIMUM RATE OF FLOW FOR BUILDING
			gpm.
5	Flushometer	Yes	35.0
6	Tank	Yes	15.0
12	Flushometer	No	39.0
13	Tank	No	18.0
28	Flushometer	No	65.0
25	Tank	No	30.0
32	Tank	No	26.0
41	Tank	No	31.0
49	Tank	Yes	41.0
73	Tank	No	45.0

After the installation had been completed, recording charts were made and the maximum demand in these sixteen-apartment buildings varied from $7\frac{1}{2}$ to 15 gpm.

Elkhart, Ind.

Charles L. Link, Manager of the Water Works, made a very exhaustive study on a fifteen-family apartment building which was serviced by a 2-in. meter. After making numerous charts covering several months' time, he came to the conclusion that a $\frac{3}{4}$-in. meter would do the job as well as a 2-in. meter because the maximum rate of demand of the building was $11\frac{1}{4}$ gpm.

Indianapolis

H. W. Niemeyer, Superintendent of Distribution of the Indianapolis Water Company, has made one of the outstanding contributions along this line. The studies are particularly important and interesting because they make a definite comparison between a flushometer type of toilet and a tank type. Although he has made numerous additional findings and records, Table 4 gives some idea of the extent of his work.

Waukesha, Wis.

The work done by A. P. Kuranz, Superintendent of the Water Department, covers a total of 6,291 hr. of records on one-family dwellings, and indicates that only 0.2 per cent of water is used at a rate as great as or greater than 10 gpm.

Conclusions

The investigation and study indicate very clearly several conclusions:

1. The type of plumbing has a direct bearing on the maximum demand. This is definitely true when the comparison is made between a flushometer and a tank type of toilet. All figures indicate that a flushometer type of toilet installation demands about twice the water that a tank type does.

2. Despite the fact that the multiple-family house or apartment is serving many more people than a single or two-family dwelling, the maximum demand varies only slightly in the general run of examples. There are, of course, exceptions to this, but they are rare.

3. A very careful study of the papers written by the men named throughout this report will, without much doubt, clear up very largely the question, "What is the maximum momentary demand for domestic uses of water in single- and multiple-family dwellings?" In general, the demand is less than the facilities can furnish. In other words, most services are larger than they need be.

Methods of Handling Street Excavations

By D. D. Gross

IN THIS discussion of methods of handling street excavations inquiry will be confined largely to the problems which arise after a water main, or other structure, has been installed and the excavation is backfilled. It is at this point that the water department personnel would appreciate being relieved of any further responsibility; but other city departments, usually the street department, are reluctant to assume responsibility until they consider conditions right to make permanent repairs to the pavement. There are some exceptions to the rule, and in some cities permanent repairs are made immediately following the backfilling of the trench; but in most cities, and especially in the case of the cheaper grades of pavement or surfacing that may be used on streets subject to the lighter traffic, permanent repairs may be delayed for a long period of time. If the street department delays repairs for one reason or another, e.g., weather conditions, especially severe winter weather, for how long should the water department be charged with the responsibility of keeping the street in safe condition at the place where it has made excavations days and even months before? In New York City, the limit is 30 days; in Baltimore, 60 days.

Since a number of problems of this nature presented themselves, it was felt that a knowledge of the experience of other cities would assist in their solution. To acquire this information, a questionnaire was prepared and sent out. Including the data from Denver, 59 replies were received from cities ranging in size from Cheyenne, Wyo., to New York City and including representatives throughout the U.S. and Canada.

Replies to the questionnaire indicated that of the 59 water departments for which data were given, 47 are considered responsible until permanent repairs are made, and 12—Atlanta, Buffalo, Lexington, Lincoln, Little Rock, Nashville, Philadelphia, Phoenix, San Francisco, Seattle, Springfield and Toronto—are relieved of responsibility when the backfill is completed, or, in some cases, when certain temporary surfacing placed. The San

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Francisco Water Department, however, purchases its immunity by letting a yearly contract covering all pavement repairs, and some of the other cities receive bills from the city street department.

In 36 cities the water departments take out a permit before, or at the time they start excavation, and in 6 cities charges for a permit, ranging from 25 cents to $2 are paid. The remaining 23 water departments "make themselves at home" and do not take out permits. In Philadelphia, according to Martin J. McLaughlin, Chief of Bureau of Water, the department works on what is known as an emergency permit issued by the Bureau of Highways, for which there is no charge. After excavation and backfilling is done by the Water Bureau, the trench location is turned over to the Highway Bureau for maintenance of trench surface and the restoration of paving, the responsibility of the Water Bureau ceasing after completion of the backfill.

Temporary Repairs

Traffic on business streets and heavily traveled boulevards quickly displaces unprotected fill of earth or other soft material, and a traffic hazard is created. For this reason 50 water departments report the necessity of making temporary repairs. Most of the other nine cities state that temporary repairs are made for them, and in some cases are paid for by them. In some cases permanent repairs follow the backfilling so closely that temporary repairs are not necessary. A number of water departments have more than one method of making temporary repairs, but 50 water departments use materials, as listed below, on important repairs and in some cases on all repairs:

Material Used	*No. of Cities*
Cold Patch	12
Double Layer Repair (Paper sometimes used between base and surface course)	7
Oil Surfacing Material	6
Planking or Old Material	6
Premix	5
Cinders or Gravel	5
Relaid Brick or Surfacing Material	3
Broken Stone	2
Ground Asphalt (Old pavement partly reconditioned)	2
Thin Layer of Material Similar to the Original Pavement	1
Shell	1

The tabulation shows cold patch to be the most popular temporary repair. Leon Small, Water Engineer, in describing the method of repair used in Baltimore, states: "The dirt is removed to approximately two inches below the street surface and the excavation is filled with cold patch

(broken stones mixed with approximately 17 gal. of water gas tar to the cubic yard; some stone dust is used as a binder)."

Detail of Replies

At Detroit, R. H. Stekette, Maintenance Engineer, Board of Wayne County Road Commissioners, states: "The Water Department is required to backfill and tamp the opening and to place 12 in. of crushed stone or slag surfacing which is penetrated with asphalt or tar by the county as part of their pavement replacement charge. Maintenance of the pavement cuts so made is then taken care of by the county."

Charles J. Alfke, Executive Vice-President, Hackensack Water Co., Weehawken, N.J., serving 51 municipalities, states: "After the trench or excavation is backfilled, we also maintain it in condition for traffic until permanent repairs have been made. In making these repairs we use "Kol-patch"—a mixture of tar and finely crushed stone."

S. F. Newkirk Jr., Engineer and Superintendent, Water Department, Elizabeth, N.J., says that they are now repairing asphalt pavement with a cold mix on a concrete base that probably will not need to be replaced by a hot mix.

In Minneapolis, cold patch is used for temporary repairs. J. A. Jensen, Engineer, Water Works Department, states: "Usually our mains have been extended ahead of paving so that we seldom have any interference in placing original mains. The cuts referred to are those resulting from breaks, leaks or other unforeseen causes, as a rule. In some cases, where the earth is mushy clay or black muck, the material is hauled away and clean sandy material used for backfill. This usually provides against settlement."

H. K. Burton, Superintendent, Water Supply and Water Works, Salt Lake City, reports the use of a cold oil mulch surfacing material for temporary repairs, stating: "This method is not at all satisfactory, as the Street Department lets some of these cuts go for months before they get around for the permanent repair. In my opinion, the Water Department should be allowed to make the permanent repair while on the job."

A double layer repair job, with base and surface courses, sometimes separated by paper, is used in seven cities, to serve as a temporary repair and sometimes as a semi-permanent repair. In either event the base course remains in service as part of the permanent repair.

W. W. DeBerard, City Engineer, Chicago, states: "The Water Pipe Extension Division (B. W. Cullen, Superintendent) is also required to barricade and red-light excavations properly when work is in progress and to maintain in good condition all openings that have been made by their forces until permanent repairs have been made by the Bureau of Streets; also makes semi-permanent repairs to all openings made by their forces

in heavy traffic streets, through-streets, pavements adjacent to street car tracks, dangerous intersections, and wherever else, in the judgment of the foreman-in-charge, this type of repair should be made. This repair consists of backfilling the trench or opening with sand, tamping in layers of 4 in. or puddling thoroughly with water, replacing the concrete base permanently and installing a plug of concrete the same thickness as the asphalt. This plug is separated from the base by tar paper or a very thin layer of crushed stone, screenings or sand. Cold lay asphalt is sometimes used to make semi-permanent repairs . . . . "

J. B. Winder, Chief Engineer, Dallas, Tex., City Water Works, states:

"In the case of large and deep excavations, temporary repairs consisting of local stone base and gravel wearing surface are maintained for a considerable time to allow shrinkage to take place before pavement is replaced.

"If the street surface is asphalt on flexible base, the temporary top usually remains as the permanent base. All asphalt surfaces are replaced by the Street Department, at cost plus.

"If the street has concrete base and asphalt or brick top, it is handled in two ways: (a) When cut is long, extending from ½ to several blocks, we put in base using Texas Highway Special cement, a finely ground quick setting cement—same cost as portland—and make arrangement with the Street Department to apply the top 24 hr. later. (b) When cuts are small, as for service installation, repair, etc., we replace base, cover base with layer of paper and lay a temporary concrete top immediately, opening cut to traffic 24 hr. later. Street Department removes temporary top and replaces with asphalt when doing other work in vicinity."

A. S. Augustus, Assistant Engineer, Louisville, Ky., Water Company, states: "In asphalt pavement cuts under approximately 50 sq.yd., we install a concrete base as per specifications by the Department of Public Works and make temporary repairs with tarmack." At a later date permanent repairs are made by the Department of Public Works.

J. J. Davis, Distribution Engineer, Memphis Light, Gas and Water Division, writes: "All street cuts are repaired with concrete by the Water Division. The base, 6 in. thick, which is a permanent repair, is separated from the 1½- to 3-in. surface by a tar-paper joint. Permanent repair to the surface is made by the City Engineering Department by removing the top layer of concrete and replacing with the original type of surface. All repairs extend 6-in. over the edge of the ditch."

J. H. Kennon, Managing Engineer, Bureau of Water, Pittsburgh, in discussing temporary repairs to street pavement, states that they use "blockstone laid flat in cement as base and paved with brick laid flat in cement to street surface."

J. S. Longwell, Chief Engineer and General Manager, East Bay Municipal Utility District, Oakland, Calif., states: "On asphalt or concrete, temporary repairs are made with oil. On oil streets temporary repairs are backfill only." For permanent repairs "the District contracts all repairs to asphalt paving and concrete paving."

In Duluth, Minn., 2-in. of oiled rock; in St. Paul, Minn., 3-in. of oil mix or "Tarvia"; and in Spokane, Wash., 4-in. of oil surface material are used on temporary repairs to pavement.

H. F. Blomquist, Superintendent, City Water Works, Cedar Rapids, Iowa, states that temporary repairs are made with "planking nailed securely to stringers in sand or soft soil, crushed stone where it will serve satisfactorily . . . . Quick setting cement is used for all cement work, and usually an excavation or new pavement repair is barricaded only 24 hr."

A. B. Wood, General Superintendent, New Orleans, writes: "The Sewerage and Water Board maintains a paving department that restores all classes of pavement with the exception of asphalt top. This department planks all asphalt cuts and follows up all cuts made by our forces to see that they are safe until the pavement is restored."

W. W. Hurlbut, Assistant Chief Engineer and General Manager, Bureau of Water Works and Supply, Los Angeles, states: "Trench is graded to a depth of 1 in. below existing street grade and temporarily resurfaced with 1 in. premix oil and rock and rolled to smooth surface by truck. In the case of long excavations paralleling curb line, the usual practice is to oil only intersections and driveways. However, on business streets and heavily traveled boulevards, it is sometimes advisable to oil entire trench to eliminate dust nuisance. All small excavations are oiled in above manner."

The New York City water department uses either temporary bituminous pavement on cinder foundation, or, at times, the removed broken pavement is replaced as temporary surfacing on main traffic streets. Cinders are used for secondary streets and in sidewalk areas.

According to Thomas J. Skinker, Water Commissioner, the St. Louis, Mo., water department uses 6 to 8 in. of asphaltic mixture replacing original surface until street repair crew can restore the surface.

Thomas L. Amiss, Superintendent-Engineer, Department of Water and Sewerage, Shreveport, La., reports the use of a material in the refill that will make a rather permanent fill until repairs can be made. He further states: "I am happy to say that we have never had an accident of any consequence due to cuts in the street for repairs or improvements; however, we carry public liability and public property insurance to safeguard financial losses from accidents."

J. E. Gibson, Manager and Engineer, Water Department, Charleston, S.C., says: "Under our ordinances the city charges us with the backfilling of all excavations and is supposed to do this; but in desperation and for our own protection, it requires that we do the work as it might be several days before the city crews could get back and fill the excavation, during which time we would be responsible and would have to maintain lights, etc. We refused to pay the city for this backfilling, with the result that there is at present a checkmate between the two departments."

W. R. LaDue, Superintendent and Engineer, reports that in Akron, Ohio, the water department makes temporary repairs to the pavement by laying brick on well tamped backfill; and on surfaced streets they use the surface material on well tamped backfill.

TABLE 1

Charges or Costs of Making Permanent Repairs to Street Pavement or Surfacing

PAVEMENT MATERIAL	NO. OF WATER DEPTS.	CHARGE PER SQ.YD.	MEDIAN CHARGE PER SQ.YD.	AVG. CHARGE PER SQ.YD.
Asphalt	45	$2.00* to $18.00†	$5.00	$5.31
Brick	32	1.50 to 10.00	5.00	5.04
Stone Block	25	.80 to 9.00	6.00	6.28
Macadam	27	.45 to 10.00	3.00	3.05
Concrete	39	2.00 to 18.00	4.32	4.68
Oil Surfacing	18	.08 to 3.25	1.75	1.75
Gravel	12	.09 to 2.90	1.00	1.13

* Water Department also charged for labor and equipment.

† $18.00 charge in Cheyenne, Wyo., probably made high to discourage the cutting of pavement.

As to the nature of repairs made to pavement in Richmond, Va., Marsden C. Smith, Chief Engineer, writes: "Depending upon the type of street, brick, spall, asphalt block, etc., are relayed temporarily. Cinders are used in muddy weather."

According to W. A. Peirce, Manager, Water Department, Racine, Wis., the department gets a "break". Whereas plumbers must deposit $35 before making pavement cuts, the water department does not pay until the work is done. Temporary repairs to surfacing are made by using crushed stone screenings, which is oiled if traffic conditions require.

In Kansas City, Mo., and in Denver, reconditioned asphalt is used in making temporary repairs. In Denver, the 2 in. layer of asphalt used is not fully conditioned. It is put through a hammer mill and before use is mixed with 7 gal. of fuel oil to the ton. This material is supplied by the paving department at $2.75 per ton for asphalt, and $0.08 per gal. for fuel

oil. The street department objects to the use of premix or oil on the grounds that the material is too difficult to remove when permanent repairs are being made.

R. L. Dobbin, General Manager, Peterborough Utilities Commission, Ontario, reports the use of a thin layer of material similar to the original material for temporary repairs.

G. L. Fugate, Chief Engineer, Water Department, Houston, Tex., reports the use of 6 in. of shell as temporary repair.

Permanent Repairs and Main Location

Permanent repairs to some kinds of pavement, usually concrete or macadam, are made by 25 water departments.

A summary of charges paid by water departments for permanent repairs to pavement and surfacing is given in Table 1. In a few cases the cost of work, when done by the water department, was given and these figures have been included.

In Denver the charge paid by the water department for permanent repairs to pavement in the year 1941 was $12,617.23. This was the payment made to the street department, and the costs to repair or maintain pavement or surfacing temporarily were in addition.

The reports show that 50 water departments have a definite location in the street in which to lay water mains, but nine water departments report that they do not. Most water departments will, under favorable conditions, lay pipe back of the curb line to avoid cutting pavement; two reports are no, but 55 say yes. Although they sometimes lay mains back of the curb, three departments find the practice objectionable, and three make it a practice to lay mains back of curbs.

E. F. Dugger, General Manager, Newport News Water Works Commission, states: "Where a street is to be resurfaced with permanent pavement over a large supply main it is often advisable to lay small mains inside the curb on both sides of the street and connected at both ends of the block to the supply main."

Good and Bad Practices in Tank Maintenance

By Walker B. Davis

A LAWYER who appears before a group of engineers, at a technical meeting, to talk about good and bad practices in maintenance of elevated tanks perhaps owes his audience an explanation. This author has had to borrow liberally from the writings and speeches of members of his company's operating department in order to have anything at all to say about *good* practices in this field; however, in the course of legal activities the author has learned something about some very *bad* practices from which the owners of elevated tanks have suffered.

Everyone knows, of course, that steel will rust if it is not painted and it is generally appreciated that an elevated steel water tank should be cleaned and painted periodically. There are many reputable companies and individuals who do this work and do it well. A few unscrupulous concerns, however, have made contracts for cleaning and painting tanks an excuse for doing a great deal of unnecessary work which they call "repairs" and for which a considerable number of municipalities have paid many times what it would have cost to have their tanks cleaned and painted by honest contractors. These concerns have extended their activities into almost every section of this country. Their energy, their skill as salesmen and, it may be added, their ability in court are really amazing. Indeed, it would seem that they could earn an honest living with much less effort, and certainly with much less risk, but apparently it is more fun to operate a racket.

Cleaning and painting a tank is merely incidental as far as these racketeers are concerned. It serves as a convenient starting point for their real objective. They take a cleaning and painting contract at a low figure, but they slip in a clause which permits them to replace loose and defective rivets, and to weld pits, at so much per hour, or so much per rivet, or on some other basis which makes it profitable for them to replace as many rivets and weld as many pits as possible. Once they get such a contract,

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they do a minimum of cleaning and painting, and concentrate their efforts on cutting out rivets as fast as they can. When they have cut out so many rivets that the tank is completely unserviceable, they sometimes demand a written order to replace the rivets they have cut out, and they tell the municipal authorities that if they do not get such an order they will go away and leave the tank as it is. This threat, of course, is an effective one, because if it is carried out the town will be without water until someone else can be found to put the tank back into service.

Rivet Replacement Racketeering

The Village of Dexter, near Ann Arbor, Mich., has an elevated water tank that was built in about 1927. In 1940 a tank repair company persuaded the village authorities to enter into such a contract as has been described. The painting was done without adequate cleaning of the steel, so that less than a year later it was possible to remove large pieces of paint with one's fingers, and there was a good deal of rust on the inside of the pieces that were removed. There were about 4,275 rivets in the shell and bottom of the tank; 4,198 of these rivets were cut out and replaced—in other words, all but 77 of the rivets in those parts of the tank on which any work was done. The village received a bill for about $4,300 covering over 1,700 man-hours of extra work which was done under the supposed authority of the clause authorizing the replacement of defective rivets, etc. The village had already paid $1,300 before the fraud was discovered, but refused to pay the balance, and the tank company brought a suit to enforce payment. The case was tried in the Circuit Court at Ann Arbor. The evidence disclosed that an inexperienced foreman had been put in charge of the work and that, as the trial judge said, the service was less than valueless—it actually damaged the tank. Fortunately, the trial resulted in a decision in favor of the village, but the village was put to a great deal of unnecessary expense, and the village officials were greatly inconvenienced, even though the contested bill did not have to be paid.

Things like this have happened in a number of other towns in various parts of the country. There is a lawsuit pending now in which the town of Illmo, Mo., is seeking to recover damages because a large number of sound rivets were cut out of its tank and the town had to get someone else to restore the tank to working order after these depredations had been committed. The town of Enfield, N.C., had a somewhat similar experience. The State of Michigan had to defend itself in the Court of Claims against a large bill for the removal and replacement of rivets that were not defective. And so the list might be continued. If the public officials discover that they have been imposed upon before they have paid the bill, they can defend themselves in court, but that is not a very satisfactory

remedy, as a lawyer must be the first to admit. The real solution, of course, is prevention and there seems no way to prevent such occurrences except to familiarize municipal authorities and water works engineers with the facts and keep repeating them almost incessantly, so that the things one group of officials has learned will not be lost sight of when their successors take office.

The Facts on Tank Rivets

Rivets in elevated water tanks are quite commonly driven with flat heads on the inside of the tank. These flat heads have rough, irregular surfaces, and after they get a little rusty, it is easy for an unscrupulous person to lead municipal officials to believe that the driven head on the inside of the tank was originally round and smooth, like the manufactured head on the outside, and that most of the inside head has rusted away. Actually, of course, the amount of steel lost by rusting is insignificant and the rivet head is practically as good as it ever was. Some lawyers have compared the weight of rivets driven experimentally with the weight of rivets which one of these repair companies had cut out as defective and have found that there was very little difference. In the Dexter case, witnesses testified that the hammer marks which were made when the rivets were originally driven could still be seen on some of the heads that had been cut out of the tank.

Even if the inside rivet head has largely rusted away, the rivet does not need to be replaced, as long as it stays in its hole and does not leak. The rivet head is for the purpose of water-tightness. It is the shank of the rivet that carries the shearing stresses. The important point to remember is that if the tank does not leak the rivets are not defective, and there is no occasion to replace them.

Occasionally small leaks develop around rivet heads where the steel of the rivet head is not in contact with the steel of the tank plates. Except in unusual cases, where corrosion is very severe, such a leak can easily be stopped by the use of ordinary hand-calking tools. It is not necessary to replace the rivet and the chances are that anyone who wants to replace it either doesn't know his business, or knows it too well, and wants to take advantage of the municipal officials with whom he is dealing. In either case, he is not the sort of a person who should be allowed to do any work on an elevated tank.

If a tank has been neglected the steel plates may become pitted because of rust, and in extreme cases the rust may have eaten completely through the plate, leaving a hole through which water can escape. Such a condition can be temporarily corrected by inserting a patch bolt which will

close the hole and will often suffice for several years. Welding of pits and leaks is of doubtful value, because the heat which is generated in the process of welding often causes new leaks, and even if a considerable area is welded, other leaks are apt to appear relatively soon. In ordinary cases, where the pits are not serious, the best procedure is to clean them and repaint them without attempting to fill them. The only complete remedy in serious cases, of course, is the replacement of the plates which are involved and that should be done only by someone who is thoroughly competent to do it.

Other Unscrupulous Practices

Another source of income to unscrupulous tank repair companies is the replacement of spider rods. While a tank is being erected these rods are placed across the top of the tank shell, under the roof, like the spokes of a wheel, but they are really nothing more than pieces of erection equipment, and they have no permanent value to the tank. Spider rods rust out rather rapidly, because they are alternately under water and above it, and consequently they can be pointed out to the uninitiated as horrible examples of the things rust is doing to a tank. They look enough like structural elements to convince many people that they are necessary to the stability of the tank, whereas in fact they are of no importance once the tank has been built, and there is no occasion whatever to replace them if they rust out. The suggestion that the spider rods need to be replaced ought to be a danger signal and ought to lead municipal officials to avoid any dealings with the man who makes it.

Another favorite scheme of the racketeers is to convince the owner of an elevated tank that the sway rods are in need of adjustment and that the tank is likely to collapse if they are not tightened before the wind starts to blow. This is very definitely a false alarm. The author has never heard of a case where adjustment of sway rods was necessary to prevent a tank from collapsing. The rods are carefully adjusted when the tank is built, so as to distribute stresses uniformly throughout the tower, and ordinarily the original adjustment is sufficient. If any subsequent adjustment is needed, the work should be done by an expert or else the original balance will be disturbed and serious distortion may result. The itinerant tank fixer is not very likely to be competent to do that sort of work.

One of the tricks of these outfits is to change the names under which they operate after the news spreads that one or two towns have been defrauded. The author knows of one man who operated for a while under one firm name, then went to work for his wife, who operated under a different firm name, and finally had his own name legally changed and began to operate from new headquarters under still a different firm name.

Builder's Inspection and Advice

If an elevated water tank is thoroughly cleaned and painted with reasonable frequency it should have a very long life. A recent survey of 111 standpipes along the New England seacoast, where weather conditions are most unfavorable, showed that 67 tanks were still in use, and that their average age was 47 years. Only 12 tanks had become unsafe after 35 to 40 years but 32 had been superseded by elevated tanks or had become inadequate to meet increasing demands for water. It is very unlikely that even a tank which is 30 years old will need extensive repair, unless it has been very badly neglected, and if it has been neglected, the neglect will be evidenced by leaks if the consequences have been at all serious.

If a tank does develop leaks, the remedy is usually simple and inexpensive. The safest thing to do in such a case is to notify the company which built the tank and ask for an inspection. The builder will be glad to inspect the tank for a nominal charge and will tell the owner what is necessary to put the tank in good condition. Ordinarily the builder will not be interested in cleaning or painting the tank but it seems certain that any company which builds tanks has enough interest in the tanks it has built to be willing to make an inspection and advise the owner what to do if leaks develop. If something goes wrong with an automobile, one goes back to the man who sold it, and the same practice is advisable in the case of a water tank.

Proposed A.W.W.A. Specifications

When the activities of unscrupulous tank repair companies were brought to the attention of the American Water Works Association, its Board of Directors wisely concluded that it would not be sufficient merely to issue a warning, but that something constructive was required in addition to the warning. It was decided that standard specifications for cleaning and painting elevated tanks should be prepared and furnished to municipalities, so that it would not be necessary for the municipal officials to rely for specifications on those who solicit maintenance work. One of the author's associates has prepared a draft of what may serve as the basis for development of specifications by the A.W.W.A. Committee on Steel Standpipes and Elevated Tanks; and, although the scope for the ultimate specifications has not yet been decided, it has been suggested that this writer comment briefly on what should be included.

It is essential that the tank be painted both inside and outside, and the inside of the tank is actually more apt to be damaged by rust than the outside. Before the paint is applied, all dirt, rust, loose mill scale and loose paint should be removed by means of scrapers and wire brushes so

that the surface of the steel will be clean and smooth. If the condition of the steel is such that scrapers and wire brushes will not clean it properly, it should be sand-blasted, using chiefly silica grains as sharp and coarse as practicable. No greater area should be sand-blasted on any one day than can be painted on the same day. Whether the steel is cleaned with scraper and wire brushes or by sand-blasting, all rust which forms on the cleaned surface should be removed before any paint is applied.

If the old paint is in fair condition, only one new coat may be necessary, but if the steel is exposed in spots, these spots should be given a patch coat before the finish coat is applied. If the surface is in bad condition, there should be a primer coat and a finish coat, and in any event the amount of painting to be done and the number of coats should be carefully specified.

Opinions will differ, of course, about what kind of paint to use. Naturally, a good quality of paint made by a reliable manufacturer should be specified, and price should not be the controlling factor in making the selection.

The cathodic method of protecting the inside of a tank against rust is a recent development which, it appears, eliminates the necessity of painting in some circumstances, but unfortunately the author is not familiar enough with this method to discuss it and it is mentioned merely in order that it may not be overlooked.

The specification should, of course, require a workmanlike job and it is advisable to include provisions that each coat must be allowed to dry thoroughly before the next coat is applied and that paint shall not be applied during wet or foggy weather or when the temperature of the air is below 50°F. It is well known that weather conditions must be reasonably favorable in order to get satisfactory results in painting.

Recommended Protective Measures

If an elevated tank is thoroughly cleaned and painted at least once every four or five years, it is not likely to require much other maintenance and it is not likely to need repairs. Rust is the principal enemy of such tanks and its ravages can be checked by periodic cleaning and painting. If, however, repairs do become necessary, they should not be done as an incident to a painting contract. The tank should be inspected by the builder or some other competent person, the exact repairs that are necessary should be determined and one or more proposals for doing that particular work should be obtained. The work should be let only to a qualified, experienced concern of recognized standing which is known to the municipal authorities and which can give satisfactory references. Before signing a contract with a concern which is not definitely known to be reliable the references which are given should be checked, because the unscrupulous

repair companies are both ingenious and daring, and they may not hesitate to name as references people who, they know, will not recommend them if an actual inquiry is made. In one case the Chicago Bridge & Iron Co. was given as a reference by a man who, it seems certain, knew that the company had a good deal of unfavorable information about him and that it would not hesitate to give this information if consulted.

Even in ordinary times, an elevated tank is an asset which should be protected and made to serve a community for many years. At present, when the use of steel for elevated tanks is severely restricted, it is more important than ever to see that existing tanks are well cared for. All will agree that it is a serious crime to waste steel by removing rivets that are still serviceable. It is hoped that you will co-operate with this Association and with the various municipal leagues and "better business bureaus" in exposing the rackets described and giving public officials the facts as to what is necessary for the maintenance of elevated tanks and what is not only unnecessary but positively harmful.

If you know of any cases where municipalities have been victimized, and if you are in a position to substantiate the facts, you are advised that the A.W.W.A. would like to hear from you. If you have or can obtain any evidence of violation of state or federal law, you will be doing a public service by turning over such evidence to the proper authorities, so that they can prosecute the offenders and discourage the racket. The author will be glad personally to do anything in his power to assist anyone who can and will take action to put an end to such practices.

Identification of Micro-organisms in Relation to Water Purification

By James B. Lackey

THE water works group is a progressive one, ever seeking better and cheaper water for the consumer. Better water means freedom from organisms, their organic debris and secretions, as well as tastes and odors. This continually demands investigation and requests are frequently received asking for literature which will help identify various organisms found in water supplies. As more is learned, the rôle of micro-organisms other than bacteria takes on more importance. They not only may cause tastes, odors and colored or turbid water, but they may shorten filter runs and play a part in the obstruction of pipes. Lately there has been an indication that some of them may protect bacteria against chlorination.

Some organisms are resistant to very heavy chlorination. There is only a small number of such species, but this group is illustrative of the fact that even such a restrictive environmental niche as heavily chlorinated water has some inhabitants, and not infrequently it is these forms, peculiar to extremes of environment, which are significant, rather than those which tolerate a broad range of conditions. Among those which tolerate continuous exposure to residual chlorine up to 0.2 ppm. are some blue-green algae, as *Gomphosphaeria aponina* (Fig. 1), and a very small green alga, *Cosmarium sp.* (Fig. 2), which illustrate the point; although this is, of course, not a heavy chlorine content.

Before identification it is necessary to catch the organism. What is in a catch depends on where and how the sample was taken:

(1) If the sample was taken in the open water of a reservoir, suspended forms, for which the term plankton is used, are obtained.

(2) If the sample is a bottom sample, attached or crawling forms—benthos—are obtained.

(3) With a coarse net sample, the smaller forms are missed; even with a plankton net, 173 meshes to the inch, some very small organisms are still missed.

A paper presented on June 22, 1942, at the Chicago Conference by James B. Lackey, Sr. Biologist, U.S. Public Health Service, Cincinnati, Ohio.

(4) Dipped samples centrifuged at speeds as high as 20,000 rpm., lose many soft bodied forms by disintegration. Such centrifuging, together with the Sedgwick-Rafter method, is advocated in *Standard Methods* (1), but the writer believes a simpler method is more inclusive and accurate.

Examination of Samples

If only the large plankton organisms are to be studied, a plankton net sample is sufficient; but if the smallest ones are wanted, a dip sample, taken at the desired depth, or a composite dip sample from various depths, should

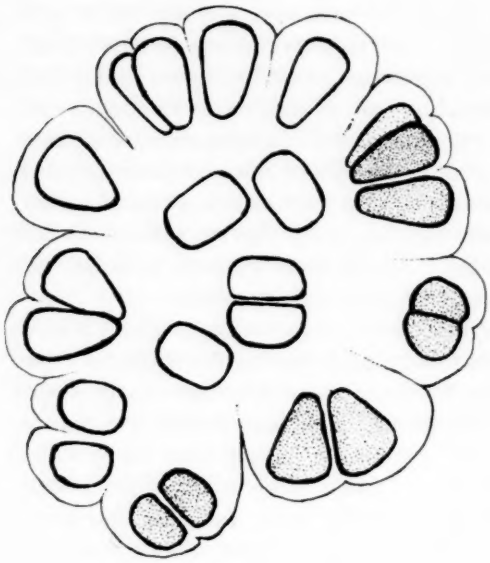

FIG. 1

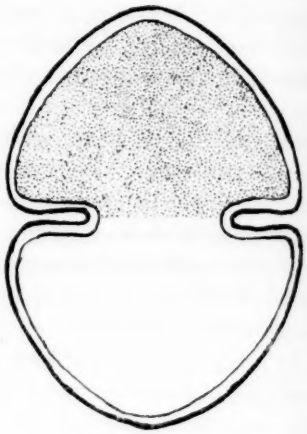

FIG. 2

FIG. 1. *Gomphosphaeria aponina;* a blue-green alga in a gelatinous capsule, from a finished water reservoir

FIG. 2. *Cosmarium sp.;* same source

be secured. This may be treated several ways. Probably the best is to centrifuge for 5 min. at about 2,500 rpm. and examine the catch alive. Except in waters of extreme clarity or paucity of organisms, the catch by such a method is about 90 per cent accurate. There are occasional exceptions; it is well known that some few organisms are thrown to the top instead of the bottom of the tube. Small amounts of water (100-ml. portions) may be used and, from long experience by the writer, have been found to give average samples, if correctly taken and well mixed. A small motor-driven centrifuge whose head will take two or four 50-ml. tubes is used.

After centrifuging, the supernatant may be decanted by pouring off until about 20 drops are left, containing the catch. It should be emphasized that some practice is necessary with this, as with any other method.

Use of a counting chamber for microscopic examination is discouraged in preference to a drop method. A medicine dropper type of pipette, but at least 6 in. long is used to mix, measure and deliver a portion of the catch. Graduated pipettes generally have too small an aperture. Time is saved in enumeration if some standard ratio, as 20 drops = 100 or 50 ml. is adhered to.

After mixing, the drop to be examined is placed in the center of a slide and a square 25-mm. cover glass is dropped on it. This often leaves a small bubble, but not a troublesome one. If the cover is dropped at an angle, organisms are crowded at one side, i.e., the drop is not uniformly spread. Tilting the slide generally corrects this. Cover glasses of No. 1 thickness should be used. Organisms may be counted by taking two paths across the slide at right angles to each other; for practical purposes, at 125 diameters two such paths contain the organisms in one-tenth of the drop. The mathematical factors, however, must be figured carefully, for they depend on width of path.

Handling of Samples

If this procedure seems meticulous, it is none-the-less rapid, easy and accurate. Furthermore, it allows for quick examination of a micro-organism with either high or low power of the microscope. A more detailed account of the procedure, with data, has been published elsewhere (2). In this, as in any method, there are some inherent sources of error. One is uneven distribution; another is the fact that some organisms move at will, and rapidly, while others either follow the lighted spot above the condenser, as the slide is moved across it, or collect at the lighted side of the drop. One important point directly concerned with identification, is that the temperature of the sample must be kept near the point at which collection was made. Quick increases in temperature are fatal to many organisms, causing them to cytolize and become unrecognizable. This is true of species of *Synura*, *Mallomonas*, *Chromulina*, *Uroglena*, *Cryptomonas* and certain ciliates. In addition, it generally affects the olive-green flagellates (the Cryptophyceae) and the yellow flagellates (the Chrysophyceae) more than any other groups. Since those two groups contain some of the worst troublemakers, this point is worth remembering. A cold drop of water warms quickly on a slide, and work on it should be done in the first 10 or 15 min. if the temperature difference is 10°C. or more.

Frequently it is not feasible to examine samples when they are taken. Storage overnight is permissible, but only when a very pronounced drop

in temperature obtains in the place of storage. Dropping the temperature, even from 30°C. to 3°C. does not hurt organisms for as long as 24 hr. (however, it makes them susceptible to death and cytolysis if the temperature is quickly raised), but after 24 hr., changes are apparently cumulative and the sample soon becomes useless. It has been field practice to preserve samples which are to be examined later. For this, 3 to 8 ml. of formalin (40 per cent formaldehyde solution) per 100 ml. of sample, provide the best preservation. Alcohol is very poor, and various other preservatives have been tried and discarded in favor of formalin. It is added as soon as the sample is taken; the sample is then shaken and stored in the dark. One practical value of this method is that organisms gradually settle after preservation, so that if wide-mouthed jars (as Mason jars) are used for storage, the supernatant may be siphoned off in a week or ten days, and the catch thus contained without centrifuging.

Objections to Preserved Samples

Objections to using preserved samples are several. First, many organisms are detected, especially by the inexperienced, by movement, and certain species have characteristic movements which greatly facilitate identification. Second, definitive forms and types of shape are frequently lost after formalin preservation. This is particularly true of naked forms as amebas and species as *Cryptomonas erosa* or *ovata*. Figure 3 shows the definitive type of shape of three amebas alive, and its loss on preservation. Figure 4 shows changes in *Cryptomonas*, on preservation. There are varying degrees of this loss of shape too; sometimes *Cryptomonas* may be recognizable; at other times there may be left only two diffuse color spots with two irregular rows of starch granules to indicate where the animal has gone to pieces. A second type of change of shape is the disintegration of a colony, which *usually* occurs when *Uroglena* or *Synura* are preserved.

A third objection is the loss of color. Here again the Chrysophyceae and Cryptophyceae are the worst sufferers, their pigments being water soluble and quickly disappearing. The chlorophyll of green forms will disappear often within a week or ten days unless they are stored in the dark, and the red pigment of eye spots usually disappears in 24 hr., even in the dark. Colors of shells rarely disappear and the diatoms lose their color very slowly.

Despite these objections to formalin preservation it has been generally used in the laboratory. A mixed sample examined alive, and then after being stored for a year in formalin, showed only about 15 per cent difference in enumeration, whereas two examinations of the same sample may show that great a difference. In routine sampling too, the worker soon becomes familiar with the changes wrought by formalin, so that, after a while, very

few organisms are missed. The writer has consistently examined samples more than a year old. Such preservation is also useful because anyone can do the sampling and preservation with practically no equipment and the samples can be sent long distances for examination.

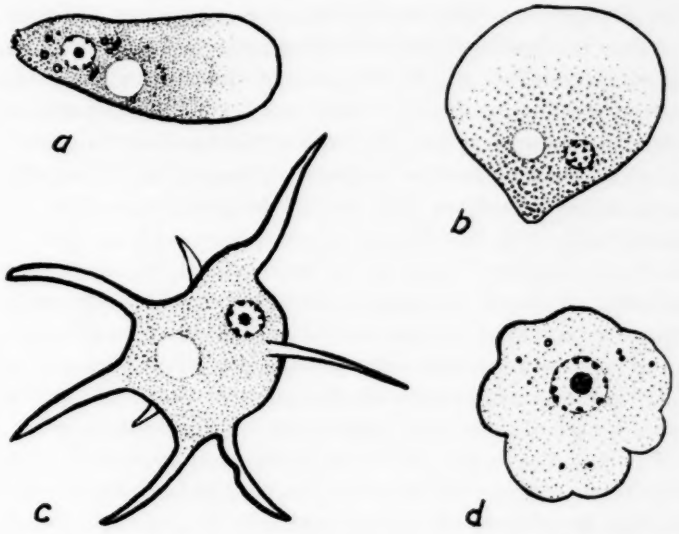

FIG. 3. Three Small Amebas, *a*, *b*, and *c*; in characteristic living shapes—after formalin preservation they may each appear as in *d*

FIG. 4. *Cryptomonas erosa;* an olive-green flagellate; *a*, after a brief preservation in formalin; *b*, after prolonged preservation

Problems of Identification

The foregoing applies to the statement that it is necessary to catch organisms before identifying them. It outlines, in a sense, the treatment of the organisms to get them into the best condition to be identified. For the

actual identification there is no "royal road," but the road may at least be shortened. There is no virtue (and but little chance) of identifying *all* the micro-organisms in many samples. For example, there are usually 75 to 100 species of plankton organisms in a single 100-ml. sample of White River water in July. These may come from animal and plant groups totaling 50,000 species. This last figure over-emphasizes the task, however, for in the examination of about 5,000 samples of river water, the writer has found only about 500 genera or species of identifiable forms, with perhaps another hundred of "unidentified" species, and no single common form in this assemblage has remained unidentified at least to genus. This number has likewise included two categories: those which occur with some frequency and those which are rare, or of infrequent occurrence. Even a rare organism may occur as a bloom.

Obviously the common forms should be identified, for they contain the troublemakers. If a rare organism becomes a troublemaker, it may be looked up, or a preserved sample sent to an expert for identification and remarks. If one is an expert with photography, photographs may be obtained. Very few people are sufficiently expert to get pictures showing enough detail, and the time and expense generally are prohibitive.

The term "common forms," however, is not cosmopolitan in its application; for example, there were about an equal number of common forms, approximately 30, in Lake Bachman, from which the Dallas, Texas, water supply is taken, and in that area of Lake Michigan supplying the south side of Chicago, in April, yet only a few species were common to both. Curiously enough, Lake Michigan at that time contained as a common form, a species of small colorless flagellate which had been described (3) only a short time previously as a new genus and obviously a rare species, since the only previous record was from the Tennessee River. It illustrates the point that the worker should identify the common organisms in his particular case, even though they may not occur elsewhere. Furthermore, a particular species may give trouble in a specific case, even if not encountered in other situations.

Procedure of Identification

Perhaps the first step in identification is knowing the accurate use of a microscope. The second is knowing how to make a good slide—a wet mount. These are matters of practice, but are not second nature, to a chemist, for example, who is suddenly called upon to make a microscopic examination of a water supply.

Familiarity with the general field is also a requisite; it is a very easy matter to be confused by debris, pollen grains, fungus spores, cysts and artifacts of various kinds. Many such objects represent potential living organisms,

but generally it is difficult to say what particular one. No worker in the biology of water supplies should be without access to Whipple's *Microscopy of Drinking Water* (4); it is to be hoped that a revision of this book, or a new one along the same general lines, will soon be forthcoming.

All too frequently, however, the complaint is made that an organism does not look like the illustration in some book. This is true both for drawings and photographs. These usually represent optical sections of an organism and must be supplemented by some description. When one recalls the trouble the bacteriologists take to identify a single species of bacteria, it is not too much to expect to read a description as well as to look at a picture.

Beyond the knowledge of the general field, one becomes almost at once a specialist. This means that for almost each group of organisms, technical literature must be consulted, and frequently there is no single book covering even the group.

Ward and Whipple's *Fresh Water Biology* (5) is another general book, covering all of the microscopic groups. But a general text can treat only a few (and not always the common ones either) of each group. For example, on page 265 in Ward and Whipple, there is an illustration of a small, green, motile alga, *Chlamydomonas*. Now *Chlamydomonas* is common in most waters. To become more specific and look it up in Gilbert Smith's *Fresh Water Algae of the United States* (6), one finds that this excellent general book for the common species of algae figures two species, stating that little is actually known of the species occurring in the United States. So reference is made to a monograph of the genus, a German text (7), to find that this text describes and figures 146 species of *Chlamydomonas*, with a few others of doubtful affinity!

Of course, this is an extreme case. Actually is it necessary to trace an organism so accurately? Most of the species of *Chlamydomonas* behave in the same general way. Might it not serve as well to trace the organism to genus? Even there one frequently runs into difficulty, which may be illustrated by the *Chlamydomonas* figures on page 316, and the *Sphaerellopsis* figures on page 317 of Smith's book, referred to above. It is difficult to distinguish between these except by very careful examination. The real answer to the question, however, depends on what use is to be made of the information. For example, if one wishes to state "The large numbers of *Euglena* present indicated heavy pollution," the statement is incorrect because the information is inadequate; some species of *Euglena* will not tolerate even moderate pollution, regardless of statements in the literature to the contrary. It seems there has been too much loose usage of generic names with regard to algae and some other microscopic organisms, relative to water ecology. Such usage is sure to make the interpretation of results uncertain.

The identification of micro-organisms for the non-specialist is by no means hopeless, however. Common knowledge of perhaps 200 species would cover the field, and by some reading and references, one may locate adequate illustrations and descriptions of these. At the same time one is acquiring the necessary background on where to look for others.

This figure of 200 species is a yearly average too, for some organisms do not occur in summer, others in winter. It is rare that a sample—at least a 100-ml. portion—contains more than 75 species; usually it is less, and about $\frac{1}{3}$ to $\frac{1}{4}$ are common, that is, they appear time after time, while the other $\frac{2}{3}$ or $\frac{3}{4}$ are seen only occasionally. Thus in 24 300-ml. samples taken from Lake Michigan at the Dunne Crib intake, between March 18 and May 1, less than 100 species were found, and only 26 recurred time after time. Of the frequently recurring species, one is probably new to science, and one other would not have been found in easily available literature. In the case of an unknown organism that occurs rarely but in large numbers, or one whose numbers are small, but whose recurrence is frequent, it is advisable to give it a provisional name, even if that name be Helen (as a co-worker named an unknown) and to make sketches. The organism is thus always accounted for, and the sketches, with preserved or living material, can be shown at some appropriate time, to a specialist. Specialists are always curious about anything new in their line.

Characterization of Microscopic Forms

Using such procedure, it is gradually possible to account for almost every form in the water studied. There are usually only four groups of organisms containing microscopic forms for identification. These are Rotifera, Protozoa, Algae and Bacteria. If one samples the mud and debris from the bottom of a stream, lake or reservoir, there are nine additional animal groups which might be encountered, but which rarely occur in abundance. These may be commonly, but not always, recognized by a brief characterization:

1. *Mollusca, or shellfish:* Few microscopic adults, but even young have a bivalve or univalve shell. Do not swim much, but creep.

2. *Crustacea:* Large and diverse group, varying from the swimming bivalved ostracods to the red water mites. All the young have three pairs of conspicuous swimming appendages, and all the adults have conspicuous swimming or creeping paired appendages.

3. *Insecta:* Extremely diverse group, but only a few are microscopic. These are mostly the young, and are generally worm-like and conspicuously segmented as chironomid or mosquito larvae.

4. *Oligochaeta:* These worms, as Tubifex, are generally conspicuously segmented, with tufts of lateral bristles.

5. *Nematoda:* These "vinegar eel" worms are not segmented and have no bristles.

6. *Gastrotricha:* These are seldom found; they generally have a rounded head with conspicuous tufts of bristles from it.

7. *Turbellaria:* These small active worms are clothed with fine cilia; usually a very evident mouth.

All of the above are as a rule active. In addition there are two sessile groups.

8. *Porifera:* The sponges are usually shapeless, green masses, not microscopic, but their spicules are sometimes found.

9. *Bryozoa.* Sessile, branching, brown forms, sometimes in conspicuous jelly. Only their reproductive bodies are microscopic.

To know these above groups, there is no substitute for familiarity with, or review of, a standard text. One has to learn the difference between an organism enclosed in jelly and a naked one; to learn that sponges just aren't found except in pure water. But there still remain the Rotifera, Protozoa, Algae and some iron or sulfur bacteria.

Rotifera are colorless, appear to be complex in structure even to the inexperienced observer, and always have conspicuous cilia, usually in rings, at the anterior or front end. Protozoa are usually colorless, and the free living forms generally simple in structure. Like the Rotifera, they are actively motile, which is frequently a grief to the observer. Algae are usually green, but may be red, brown, yellow, blue or rainbow-hued. And the iron and sulfur bacteria beggar description, varying from refringent black spheres as in Chromatium to vivid purple masses, or enormous gray tufts of filaments.

Intermediate Forms

The casual investigator of these last four groups will probably consider the entire above characterization a masterpiece of understatement when he observes that in the rotifer *Floscularia*, the cilia become enormously long hairs, lazily waving; or notes the complexity of an enormous colony of the ciliate *Carchesium* in a foul stream; or notes that the vivid green *Paramecium bursaria* is a ciliate and the vivid green *Pandorina* is an alga which swims rapidly; or notes that the band of brown in his storage reservoir is a teeming cloud of rapidly swimming dinoflagellates which a botanist doubtless calls Protozoa and a zoologist doubtless calls Algae; or that the blue-green algae are sometimes colorless, and virtually impossible to tell from the sulfur bacteria.

Such exceptions, however, are not commonly met with; and one soon appreciates that in these primitive organisms it is only natural to find intermediate forms between the Algae and Protozoa. Since it is in these

intermediates that some of the troublemakers as *Synura*, *Dinobryon* and *Uroglena* belong, and some of the indicators of water condition as *Chrysococcus* and *Euglena viridis*, familiarity becomes established. And before long the worker realizes that he has a usable knowledge of the various groups, that he is familiar with the common forms in his field and that he knows where to look up the uncommon ones.

The procedure might be summed up as follows: (1) View your organisms, typical forms in a typical state. (2) Review your literature. (3) Name those you can, and likewise those you can't. (4) Draw, describe and preserve the unfamiliar ones. (5) Consult a specialist about the last group.

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ABSTRACTS OF WATER WORKS LITERATURE

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WARTIME WATER WORKS PROBLEMS

Proneness to Damage of Plant Through Enemy Action. HAL GUTTERIDGE. Inst. of Mech. Engrs. (Br.) **147:** 99 (June '42). Paper aims to point out facts that underlie reaching of a rapid est. of damages done to a plant through enemy action. Damage may vary from slight to complete loss; damage risks greatly increased in time of war, include not only peacetime risks of fire, explosion, etc., but also danger of damage through direct hits from H.E. bombs, from pressure-wave generated by explosion, fire caused by incendiary bombs, falling debris and sometimes, flooding. "Probable proneness to damage" of plants from dropping of high explosive and incendiary bombs from aircraft, set down. Extent of damage likely to occur is function of: (1) type of bomb and location of falling; (2) type of bldg. constr.; (3) inflammability of material adjacent to fire; (4) phys. characteristics of various items of plant. Amt. of damage done by H.E. bomb, aside from its size, depends on type of bldg. constr. and to lesser degree on bldg. size, no. of floors and position of adjacent bldgs. Effect of incendiary bomb will depend primarily on roof. Fire risk per unit area of plan greater in multi-floor than in single-story bldgs., because exposed wall area open to entrance of incendiary bombs which may fall at angle to 16–46° to vertical. Fire usually found much more destructive than blast. Fully framed bldg. has shown undoubted great superiority in resisting aerial attack in comparison with old type bldg. in which walls bearing loads are of brick or stone. Walls may be used as protective device, can be arranged to divide plant into number of "cells" so that effect of a bomb explosion localized. In future factory layout, such arrangement for protection should be incorporated in design as matter of good practice, for example, in glass-bottle works, vulnerable brick-built furnaces would be separated by concrete silos holding raw materials so that at least ½ of works would be saved in event of explosion. In a single-floor light engine works, different types of machines would be separated into convenient cells by dwarf walls, etc. In factories with brick-built load-bearing walls, collapse of walls will generally cause complete collapse of structure. If walls at ground floor level are at least 14″ thick, plant inside may be expected to be protected from blast and flying debris from outside. Adequate drainage to conduct away the abnormal quants. of water present during fire fighting will reduce damage to plant at or below ground level. Extent of damage likely to be least where bldg. is of steel or reinforced concrete constr. 5 main causes of damage to factory plant consequent upon enemy air-attack are: (1) direct hit from H.E. bomb; (2) blast pressure wave from bomb explosion; (3) fire from incendiaries or, indirectly, from other type bombs; (4) falling debris

from above; (5) flooding or drenching by water. Each type of plant, depending upon its physical characteristics, has a "proneness to damage" which can be predicted beforehand. Convenient to denote this variable proneness to damage by a number which will indicate the percentage of the value of the item (in its condition just before the incident) which has been lost by damage it has suffered. Might be called "damage proneness number" or "dpn." An anvil, which would be unlikely to suffer any or but slight damage would be given a set of limits for the dpn. between 0 and 5; some recording control equipment as a thermostat would be likely to fall between 70 and 100. Limits necessarily refer to avg. cases. Heavy all-metal equip. for heavy eng. industries will have low dpn.; light high-speed machines as used in cotton spinning, for example, will have comparatively high value; lathes, shapers, etc., would have dpn. value between 20 and 50. Service piping attached to structural members of plant will have value approaching 100, for none except valves worth recovering. If piping has been placed underground only vertical "runs" will be lost and dpn. will lie between 40 and 80. Elec. motors particularly susceptible to damage, but strong body protects from falling debris. General dpn. for all elec. motor equip. including switches but not distr. mains, may range from 50 to 80. Protection for turbine-generator set can be provided by a separate reinforced concrete structure. Cornish, Lancashire and fire-tube boilers likely to have dpn. of 10 to 30; vertical and water-tube boilers, between 40 and 70. Example given of est. of damage in 2-floor 1-bldg. factory, ½ acre in extent. Bldg. of load-bearing brick constr. receiving direct hit from H.E. bomb of large caliber. Result may be supposed to be total collapse with non-spreading fire breaking out in one part of bldg. (Table 1). *Discussion.* Pointed out effect of blast may not be immediately discernible; for example, particles of glass might penetrate insulation which could admit moisture and subsequent breakdown. Experience has shown cast iron very vulnerable to shock from explosion, so anything made of it would be given low dpn. Also pointed out that, in some cases, extensive loss due to water damage which, in cases of fire, often unavoidable. Modern metal-clad switchgear found to withstand H.E. bombs fairly well, dpn. between 20 and 40; has not done so well with incendiary bombs, then dpn. between 30 and 60. Dpn. of modern transformers about 40 for fire, but for blast about 80; dpn. for cables about 20–40. For fire and with paper insulation, however, proneness to damage by fire bad either in ducts or exposed, and dpn. 60–80. Author, in closing, stated that with the experience gained, "cellular" treatment of floor areas by protective walls could generally be carried out without adversely affecting rate of production flow in quant. or qual.—*Martin E. Flentje.*

TABLE 1

Approx. Est. of Damage

ITEM	VALUE OF ITEM	DPN.	VALUE OF LOSS
	£		£
Processing plant..	20,000	50	10,000
Packaging equip..	4,000	75	3,000
Conveyers.....	1,000	100	1,000
Refrig. plant.....	6,000	50	3,000
Elec. equip.....	3,000	80	2,400
Service piping....	3,000	100	3,000
Boilers.....	4,000	30	1,200
Miscellaneous....	3,000	50	1,500
Motor vehicles...	2,000	50	1,000
Totals.....	46,000		26,100

Bomb Damage to Industrial Plants. C. H. S. Tupholme. Chem. and Eng. News **20:** 896 (July 25 '42). Extent and severity of damage to equip. depend on protection given to it by bldg. Bldg. least likely to suffer bomb damage if sufficiently resilient to recover former position without strain or disintegration. Stresses suffered require proper continuity of reinforcement or soundly jointed structures with beams and columns acting as unit, true only of reinforced concrete

or steel frame bldgs. In existing works, usually possible to arrange walls to achieve high degree of protection for equip. without interfering with work of factory. Roofs and floors of reinforced concrete give more protection than if lightened by use of hollow tiles or otherwise. In one-story bldgs. of light steel frame or reinforced concrete, roofs not usually designed to be proof against incendiary bombs. In this type of factory, division of floor into cells by protective walls to localize effects of bombs or fire particularly applicable. Main causes of damage by enemy attack from air are: (1) direct hit from H.E. bomb; (2) blast pressure wave from bomb explosion, usually accompanied by flying splinters and debris; (3) fire caused directly by incendiary bombs or indirectly by H.E. bombs; (4) damage from debris falling from above; (5) flooding or drenching by water. Each cause has diff. effect on diff. types of equip. and bldgs. and these can be classified as to damage proneness. In general heavy industries will have low damage proneness number, while those using light high-speed machines have higher numbers. Damage proneness affected by composition of metal (e.g., toughness and malleability of steel vs. brittleness of cast iron), sturdiness of constr. (e.g., sheet metal ducts vs. blacksmith's anvil) and area exposed to blast. In factory piping, important factors are: (1) total length of service lines should be as short as possible; (2) piping should be duplicated within reasonable limits, second line being far enough away from first to avoid possibility of one bomb destroying both; (3) adequate protection should be given by placing piping underground or disposing it in other ways. If piping attached to structural members of bldg. and total collapse of bldg. occurs, piping will be total loss. If piping placed underground, only vertical "runs" will be lost. Elec. cables, motors, switchgear, etc. particularly susceptible to blast, fire, falling debris and especially flooding. Elec. cables should also be run in channels, watertight in this case. Elec. motors especially susceptible to damage from fire and flooding but high ratio of wt. to exposed area and secure fastening to bases minimize damage from blast and falling debris. Even so, feet of setting frequently fractured and motor dislodged. Coils and windings easily damaged by flying debris and flooding. In generating stations, protection for turbine generator setting can be provided by bldg. separate reinforced concrete structure. Fire-tube boilers usually built lower to ground and better bedded than water-tube boilers and less susceptible to damage. For rapid approx. of loss in damaged plant, following order of observation suggested: (1) general inspection of all bldgs. on site and adjacent bldgs. to obtain comprehensive impression of damage likely; (2) inquiries as to type of bomb which caused damage, whether factory recd. direct hit, and if fire followed, where and how long fire continued and whether it burned itself out or was quenched by water; (3) detailed inspection of type of bldg. constr., its condition and whether any collapse took place; (4) detailed examn., as far as possible, of whole plant, its layout, nature, and condition of all items damaged; (5) ascertainment of value of all damaged items as of immediately before bombing; (6) prepn. of schedule showing all items or groups of items of damaged plant, proneness number of each in light of conditions to which item was exposed and corresponding loss in value. Sum of individual losses gives total loss, which can be expressed as percentage of former value. In case of totally collapsed bldg., if it is decided to rebuild on spot, work involves clearing of debris, repair of equip., planning of subsequent layout, constr. of bldg. to suit new layout and reinstallation of equipment. Damaged equip. should usually be sent to mfr. for repair, rather than doing it on spot. Should be overhauled for normal wear and tear at same time, and cost of repairs allocated accordingly.—*Selma Gottlieb.*

Air Protection of Water Supply and Sewerage Systems. M. v. POHL. Gesundh. Ing. (Ger.) **64:** 300 ('41). Survey given of direct and indirect means of protection of water supply and sewerage systems against bombing, gas and bacterial warfare, based on most recent U.S.S.R. technical publications. Indirect means of protection include camou-

flage of plant and splitting up of network and works into small dispersed units. Direct means of protection include methods of deflection of blast and fire bombs from system, individual bldgs. and plant, and constr. of pumping plant, filtration plant, etc., either wholly or partially below ground level with suitable cover. Arrangements must be made for repair of drainage works, putting into operation of alternative plant when damage caused, provision of adequate water supplies for fire fighting and decontamn. and disinfection of pipelines, bldgs., etc.—*W.P.R.*

Water and War. GEORGE E. SYMONS. Can. Engr.—Wtr. & Sew. **80:** 6: 22 (June '42). General discussion of relationship of water to war, including importance of large and small bodies in military operations, provision of safe water for troops and, particularly, protection of civilian water supplies. Water as vital to war as to life itself. Water for troops usually furnished by mobile purif. units. Individual treatment kits being developed to enable soldier to treat own supply with Cl, test for adequacy of treatment and de-chlorinate if necessary. Problems of water supply and sanitation arising from modern warfare include increased demands by industry, overloading of sewage works by concentrations of war-workers, increased need for water fire-fighting and loss of sanitary facilities in event of bombing. In America, greatest possibility of damage to water supply systems from sabotage and demolition bombs. General protection measures against sabotage include fencing, guards, floodlighting, exclusion of visitors, and investigation of and provision of identification credentials for personnel. General provisions for possible bomb damage include depots of repair parts, specially-trained repair crews, auxiliary supplies and purif. units, auxiliary sources of power and emergency chlorination of sewage. Poln. by poisons or bacteria not attempted, but possibility of poln. by war gases must be borne in mind. Planning for repair and disinfection of damaged mains important and mutual-aid arrangements between communities advantageous to all concerned. Large stocks of Cl may be hazard in case of demolition raids. Precautions include reduction of stocks to min., distr. of stock to lessen probability of hit, provision of gas masks, and having hydrated lime available for decontamn. Should water supply service be disrupted, boiling best method of disinfection. In absence of source of heat, Cl compds. may be used or, if such are unavailable, addn. of 4 drops tincture of I per gal. and allowing contact period of 30 min. effective. Such methods of household water disinfection should be publicized.—*R. E. Thompson.*

Water for the South's Powder Plants. ANON. Mfrs. Record. **111:** 6: 32 (June '42). Requirements of some armament plants met or fulfilled by new radial well system of water collection. Only 7 centralized collector units needed to obtain unprecedented gallonage at 1 plant. At another, 2 units necessary to bring in 28 mgd. Collector caisson 13′ in diam. sunk to varying depths, according to local hydro-geol. conditions, and slotted screen pipes jacked out into subsurface water-bearing strata. Water, seeping into collector pipes, flows into central shaft and pumped to destination. Above 7 units sunk to depths of 80′ to 100′. Water obtained has Fe content <0.01 ppm., temp. uniform around 60°F. through yr., and used as condenser without further cooling. Of high qual. as filtered on coarse through fine sand and gravel around collector screen pipes. Can test and measure water from each of latter, simplifying proper filtration and pumping rates. Generally, extraordinarily slow, uniform filtration rate results in thorough bact. purif. as flow from each screen pipe can be regulated or shut down separately without interfering with production of others. Central shafts on 7 units, spaced at 1,800′ intervals, built up to 46′ to insure yr.-round uncontamd. water despite local flood conditions. Each shaft surmounted by 19′ x 30′ pump house with reinforced concrete floor, steel frame, with walls and roof of asbestos siding. House rests directly on caisson walls. Addnl. floor area obtained by cantilever constr. Most labor and materials on installations obtained locally.—*Ralph E. Noble.*

Water Works—Priorities and Supply Problems. NORMAN J. HOWARD. Eng. Cont. Rec. **55:** 29: 74 (July 22, '42). General discussion of priorities in relation to water supply, with particular reference to situation in Canada. Difficulty in securing approval of plans for extensions, coupled with increases in water consumption ranging from 7 to 25%, has created acute problem in some areas. Specifications for filter alum have been modified as result of conditions brought about by war. Min. Al_2O_3 content has been reduced from 17% to 15.25%, with not less than 14.75% water-soluble, max. Fe_2O_3 increased from 0.75 to 0.75 to 1.5%, and max. insoluble matter content increased from 0.5 to 9.5%. Price will be approx. same as for standard alum and increased dosages necessary will increase cost of alum addn. 10–20%. [See Jour. A.W.W.A. **34:** 1073 ('42).]—*R. E. Thompson.*

Research as Usual. ELIOT BLACKWELDER. Science **96:** 158 (Aug. 14, '42). "This is total war." Although many scientists in country already turned attention to research related to war, still thousands going along as before. Scientific research of prime value in crisis. Many good results already well known. Possible that single scientific discovery may tip scales in favor of Victory. Allowance made for following exceptions: Some investigations under way may be important later. If not finished now, will be fruitless. Certain projects, e.g., geol. surveys, must be executed now or never. Some few scientists of so little value in other occupation, might as well continue usual work. Still remains large fraction of available scientific energy of country that could and ought to be diverted to main purpose of saving only type of civilization in which science can flourish and human happiness be widely attained.—*Ralph E. Noble.*

Pointers on the Storage of Coal. J. F. BARKLEY. U.S. Dept. Interior, Bur. of Mines Inf. Circ. No. 7211 ('42). Answers questions pertaining to storage of coal. Loss of heating value on storage of all following coals except Wyoming: New River, Pocahontas, Pittsburgh Gas and Sheridan Wyoming on outdoor weathering not above 1.2% in first yr., and 2.1% in 2 yr. Wyoming Coal loss 2–3% in first yr. and 5.5% in 3 yr. Extent of slaking depends principally on rank of the coal, lower rank coals as lignite and sub-bituminous slake from weathering more readily than higher rank coals. Very little, if any, difficulty should be experienced from slaking of Eastern coals. Heating in storage from spontaneous combustion dependent upon many factors. Spontaneous heating is uniting of coal with O, same as in burning process in furnace, but proceeding at much lower rate. Observations on spontaneous combustion include: (1) all coals undergo spontaneous heating, lowest rank coals most liable to phenomena; (2) oxidation of coal substance itself main cause; (3) process operative at room temp. as soon as freshly broken coal exposed to air; (4) with Appalachian coals, oxidation begins to be appreciable at about 85°F. and increases in intensity as temp. rises; beginning temp. lower with lower ranking coals, also rate of heating increases with temp.; (5) pyrite, when present and finely divided can increase tendency of coal to heat spontaneously; (6) opinions differ as to effect of moisture; (7) other chem. factors have little or no influence. Important factor is total surface of coal area exposed to air. The greater the surface the more the chance of union with O. A good-size egg or lump bituminous coal will not have sufficient surface area to give trouble from spontaneous heating. Air moving through coal supplies O and piling coal by dumping it may cause stratification and allow entrance of air to supply O and at same time, because of segregation, provide areas that are not ventilated sufficiently to remain cool. Spontaneous heating can be prevented or lessened by: (1) storing coal under water (has undesirable feature of making coal very wet to handle); (2) compressing pile in layers with roller to prevent access of air; (3) storing only large-size coal (practicable for domestic consumer); (4) preventing any segregation of sizes in pile; (5) storing in small piles and below 6′ in height; (6) keep stored coal away from external source of heat, as hot steam pipes; (7) avoid draft of air through coal; (8) use older portions of coal first.—*Martin E. Flentje.*

Poisons and Gases as Agents of Water Pollution. ANON. W. Supply & Sew. News. **6:** 3 (Jan.–Feb. '42). Much speculation as to probability of poisoning of water supplies, either through sabotage or gas bombs. According to best information, danger rather remote, because of large amts. of chems. required, hydrolysis of chems. after mixing with water, diln. afforded and reaction of chems. normally present in supply. Although appears that poisoning of public water supplies improbable, one should not forget that it is possible and intelligent precautions should be taken. Two alkaloids which impart bitter taste are nicotine and strychnine. Nicotine sulfate, commonly known as "Black Leaf 40," toxic in quants. of less than 0.1 ppm. Strychnine less soluble in water and toxic in amts. greater than 0.15 ppm., but reasonably safe up to 20 ppm. Detection of these compds. difficult; and they are not entirely removed by treatment. Heavy metals include compds. of mercury barium, zinc and lead, but these combine readily with sulfates, chlorides or carbonates and cause loss of toxicity. Simpler water tests, which can be of great value in detecting poisons or unusual contamn. are chlorine demand and pH. Low pH might indicate caustic condition. Fish in ponds may give indication of poisons, but this should not be relied upon as satisfactory check. For complete anal. *Standard Methods* procedure should be used.—*P.H.E.A.*

STREAM POLLUTION AND ITS CONTROL

The Rivers Speak. VICTOR M. CUTTER, ROLAND B. GREELEY AND FRANKLIN A. MILLIKEN. Pub. No. 65, Natl. Resources Planning Bd., Region 1. (Jan. '42). Authors personalize 30 New England (N.E.) rivers to reproach men for polg. same with domestic and ind. wastes from 60% of pop. Stream poln. may be reduced by: (1) natural self-purif. processes (phys., chem., biol.); (2) regulating flow in dry periods; (3) storing waste for discharge in avg. or high flow; (4) indirect discharge via lagoons; (5) retarding pools or artificial lakes to provide self-purif. conditions. $5 to $10 per capita cover constr. costs of highly eff. treatment plants for domestic sewage. Annual financing and operating expenses range from $0.50 to $1.25 per capita. Unless all communities and industries along stream follow good neighbor policy, almost inevitable some down-stream people will feel deprived of water rights and privileges by upstream waste disposal methods. Basin-wide viewpoint needed to avoid disputes and law suits, and justify multi-million dollar investments in clean streams. Within boundaries, state authorities can stop poln. dangerous to health and safety. Not responsible, however, for interstate poln. except by gentlemen's agreements or special cooperative arrangements. U.S. Engr. Dept. can enforce federal laws prohibiting discharge of refuse, including oil, in natural waters or tributaries. Some interstate compacts exist. Sensible and systematic approach to stream poln. problem needed, but impossible without suitable jurisdiction device throughout basin. Federal regulation and interstate compact appear best solutions but only experience can det. which preferable. Behavior of pold. water so complicated, no one measure, phys., chem., or biol., completely dets. safe waste load under given conditions. B.O.D. measure most frequently used and translated into domestic waste pop. equiv. Of major importance when min. O_2 content essential to fish life or avoiding nuisance. Presence of disease-producing organisms detrimental to drinking water supply, bathing and shellfish production. Too great proportion of suspended solids not decomposable. Excess acidity, alk., CO_2 impair domestic and industrial supply, and injure fish life. Stream size measured by avg. Aug. flow in cfs. Seldom serious nuisance where waste load on sluggish stream not > equiv. of 100 persons per cfs. Under favorable conditions rapid streams may accommodate 4 times this value. General condition best in Vt., yet definite internal and interstate hazards exist. N.H. next best. In Me.,

N.H. and Vt., large streams seldom seriously loaded by domestic wastes, but often increase burden dangerously. In Mass., Conn., and R.I., almost every large stream heavily pold. because of great industrial development and greater pop. density. For some, not all N.E. streams, knowledge detailed as to poln. sources and what downstream uses hindered. Mass. State Health Dept. investigated all seriously pold. rivers and inventoried waste sources and types. Conn. and R.I. made many tests and located most menacing poln. sources. State officials greatly reduced poln. in Conn. by impressing upon cities, towns and industries need for control, and outlining basin-wide improvement programs. R.I. officials induced many munic. treatment plant installations. Northern states investigation less intensive. N.E. Drainage Basin Committees, functioning as advisers to Natl. Resources Planning Bd. Water Resources Com. formed Special Subcommittee on Classification of N.E. Waters. Duty to review various utilizations of inland and shore waters in N.E. and classify according to highest use. Min. qual. of receiving waters should be available according to use. Sewage treatment methods should be provided in various situations. Subcom. recommended each N.E. state appoint state com. representing state agencies and industry to apply following classification principles in each state. Waters used for: Class A—drinking sources or cultivating market shellfish; Class B—bathing; Class C—recreational boating, fishing, culturing seed oysters, or industrial supply after treatment; Class D—primarily for commercial navigation or transporting wastes without nuisance. Waters below Class D not included above. With "highest use" waters, must consider present and future use. Varying conditions may necessitate assigning different "use" classifications to various unlike stretches of streams or tidal waters and large lakes. Thus, according to *locale*, waters may include: (1) ocean harbors near large sewer outlets (largely Class D; (2) sea water not far removed from large sewer outlets, yet so situated one tide does not carry effluent to area (ordinarily Class C); (3) sea water along sparsely popd. shores relatively poln.-free, or sea water outside harbors (ordinarily Class A); (4) large rivers draining large community watersheds (ordinarily Class C, sometimes D); (5) inland streams and lakes draining sparsely popd. areas (Class A or B); (6) inland streams now receiving considerable poln. but not main carriers of wastes (Class C, often advanced to B by wastes treatment). Sub-com. report continues with recommendations as to min. qual. of receiving waters according to use, sewage treatment methods for various classifications, disposal of industrial wastes, and for co-ordinated approach to stream classification problem through individual state action. Practical poln. abatement objective is to clean river sufficiently safely to render services most important to people. Basic need for established max. poln. load to place on streams without their abasement beyond considerations demanded by health, industry, recreation and economy. Practical and economical stream use detd. wholly by local conditions. Every stream basin has individual characteristics necessitating study and treatment of watershed as separate unit. Poln. abatement successful only when intelligent and sustained effort causes most advantageous corrective measures applied first. As yet, state depts. not authorized by their legislatures to schedule for earliest constr. facilities yielding greatest benefits. Yearly, industry, municipalities, state and federal agencies spend large sums to reduce stream poln. Although much money well spent, would produce greater benefits if differently allocated. When basin entirely within state, abatement program directed by any state agency assigned responsibility and authority by legislature. When in two or more states, valley-wide com. established by interstate compact unless states concerned prefer gentlemen's agreements or eventual federal participation. Com. or agency representing all sections and interests preserves same of all states in all parts of basin. Next step, practical, well-arranged constr. program for entire basin. Finally, small but active organization must continuously watch and test stream to check maint. of com. stds.,

indicating need for revising regulations when material changes necessitate. To control poln., few wise legislative acts enabling people in each basin to develop practical poln. control program for own geographic unit promises success. In some basins, no problem exists. In others, poln. serious. Essential and sequential steps detailed under headings: (1) det. where and to what deg. abatement desirable; (2) establish valley-wide com.; (3) plan practical program; (4) budget abatement procedure; (5) administer abatement program. Appendix I, well synthesized sample poln. abatement program under hypothetical conditions. Appendix II, responsibilities of state and federal agencies concerning stream poln. Federal groups include: U.S. Engrs.; Coast Guard; Geol. Survey; Fish and Wildlife Service; U.S. Pub. Health Service; Fed. Power Commission; and Natl. Resources Planning Bd. Each N.E. state has 2, 3, or 4 of following: Depts. of Health, Inland Fisheries and Game, Pub. Wks.—Highway Div., and Conservation; Commissions on Water, Water Control and Pub. Utilities; Committees on Waters Classification; Boards of Fisheries and Game, Health, Sanitary Water, and Water Resources. Appendix III, Report of Special Subcom. on Classification of N.E. waters with recommendations to Natl. Resources Planning Bd. and to N.E. States.—*Ralph E. Noble.*

Pollution—A Perennial Headache. Robert M. Searles. Mining Congress J. **28:** 3: 30 (Mar. '42). Regularly, at each congressional session, 2 classes of bills introduced: (1) Advocating federal co-operation with states, scientific aid from federal bureau of health, financial aid to public corporations engaged in eliminating stream poln., and general attitude of co-operative helpfulness from govt. to correct existing evils. (2) Superimposing federal bureaucratic regulation upon state regulation of streams, backed by prosecutions and injunctions in federal court for infractions. Author discusses subject from standpoints of: state legislatures attempt to handle problem; unreasonable severity of some legislative strictures; application of rule of reason; effectiveness of tailings storage dams in some localities; curbing of recalcitrant operators; regulation in terms of local conditions; and complaints. He suggests that: (1) Am. Mining Congress, as representative of mining industry, continue opposition to drastic federal regulation; (2) various state organizations carefully study local legislation relating to stream poln. and try guiding same along reasonable and intelligent lines; and (3) state assns. each assume burden of seeing that mine operators within respective jurisdictions take reasonable steps to eliminate harmful stream poln. by their operations. If done, the industry can face sportsmen with clean hands and justify position on vital subject to legislators and administrators alike.—*Ralph E. Noble.*

Studies of the Effects of Industrial Pollution in the Lower Patapsco River Area. 1. *The Curtis Bay Region, 1941.* R. A. Olson, H. F. Brust and Willis L. Tressler. Md. State Bd. of Natural Resources, Chesapeake Biol. Lab., Pub. No. 43 (Nov. '41). Indus. effluents in lower Patapsco R. area many and include waste acid, distillery, tannery wastes, and copperas (ferrous sulfate) from pigment and steel indus. Latter waste most extensive and intense according to tide and disposal. Most severe effect in Curtis Bay appears to be lowered O_2 tension of subsurface waters over general region during summer when O_2 concn. normally low. Indirect deleterious effect on plankton and higher forms feeding on latter; directly on higher forms by asphyxiation. pH effect less significant. Also shown continued copperas accumulation contributes marked ecological unbalance on entire area bottom. Approx. 100,000,000 lb. ferric hydroxide should be formed from copperas disposal products in yr. Tide effects far less significant than previously thought as max. current strength, avg. 0.1 knot/hr., carries effluents $<\frac{1}{2}$ mi. from source, normally. Effect on diln. factor important. Previously recommended to dispose 1 hr. after max. tide. Though practice minimizes occurrence of visible disposal products in upper Curtis Creek, allows effluent discharge in one local mass moving only short distance before next discharge. Mass of pold.

water remains undild. with effects severe because area small though moving. Suggested, in addn. to present practice, flushing action and resulting discharge be at such rate disposal continues over entire ebb tide for greater diln., wind action and mixing. Aeration towers or spray heads to preoxidize material effective, if feasible. Resulting ferric hydroxide sludge could be dried and disposed commercially or dumped. Such procedure would minimize if not completely eliminate local water poln.—*Ralph E. Noble.*

Pollution Control in the Potomac. *A Study of the Problems to be Attacked by the Interstate Commission on the Potomac River Basin.* F. W. KITTRELL. State Govt. **15:** 79 (Apr. '42). Interstate Com. on Potomac R. basin organized May 10, '41, by representatives of Md., Va., W.Va., D.C., and U.S., to regulate, control, prevent, or otherwise render unobjectionable and harmless the poln. of waters in area by sewage, indust. and other wastes. Pa. not represented. History of movement culminating in organization traced. Topography of 14,500 sq.mi. drainage area, and included state and natl. parks, described. Sources of poln. many and varied but 2 areas present real problems. In upper river section, acid mine drainage, indus. wastes and domestic sewage combine to tax seriously, for many mi., river's natural purif. capac. At upper end of tidal section, sewage from Wash. and surrounding Md. and Va. metropolitan areas enters basin. Practical treatment methods to solve problems known. Major obstacles to progress in poln. abatement found in admin., legal and financial rather than tech. procedures. These can be overcome only by full co-operation among fed., state and local authorities. This reason why Potomac R. Conservancy Dist. created and above Com. formed. Compact powers and duties of Com. are: (1) to co-ordinate, tabulate and summarize tech. and other data on poln., character and condition of streams in Dist. and report; (2) to supplement existing information and data, secure new data by investigations, anals. or other means; (3) to co-operate with legislature and admin. agencies of signatory bodies and other interested coms. or organizations for promoting uniform laws, rules, or regulations for abatement and control of stream poln. in Dist.; (4) to disseminate pub. information on aims and purposes of Com. and on harmful and uneconomic results of stream poln.; (5) to co-operate with other fact-finding and research organizations on treatment of sewage and indus. or other waste and to institute and conduct such research and fact-finding activities; and (6) to make and, if needful, revise and recommend to signatory bodies reasonable min. stds. for treatment of sewage and indus. or other waste discharges into Dist. streams. Enforcement authority omitted from Com. powers so as not to impose Com. upon various fed., state and local agencies with jurisdictions in basin, but rather to constitute it as agency to co-ordinate activities of these authorities. This principle emphasized under articles of compact in which signatory bodies mutually agree to: (1) faithful co-operation in abatement of existing poln. and prevention of future poln. in Dist. streams and (2) enactment of adequate and, insofar as practical, uniform legislation for abatement and control of such poln.—*Ralph E. Noble.*

Disposal of Waste Liquors From Chromium Plating. C. R. HOOVER AND J. W. MASSELLI. Ind. Eng. Chem. **33:** 131 ('41). Waste of chromium in effluents from plating and bright-dipping processes causes poln. of streams and results in loss of relatively costly and scarce compounds. Investigation carried out with primary object reduction of harmful effects of chromium wastes on natural waters and on sewage treatment, and secondary object recovery of chromium. Loss of plating solns. can be considerably reduced by use of two rinsing tanks in series, and by thorough draining and shaking of work before and after plating. Typical anals. of effluents from metal-finishing plants, and of segregated waste chromium-plating solns. shown in tables. Chromium mainly in form of hexavalent chromium. Copper, nickel and cyanide usually present and apparently carried over from preliminary plating operations. Three main types of methods of

treatment: reduction of hexavalent chromium followed by pptn. of hydrated chromic oxide, direct chem. pptn. of hexavalent chromium, and miscellaneous processes involving pptn., coagulation, and electrolytic treatment. Many reducing reagents tested on small scale, and more feasible methods then tested on larger scale. Results and costs of treating wastes contg. 100 ppm. chromium by 10 methods shown in table. Three processes of disposal, using sodium sulfide, barium sulfide and scrap iron, and one process of recovery, using sulfur dioxide investigated in more detail; all of these pptd. chromium completely, reduced amt. of cyanides and produced neutral effluents. Reduction by sodium sulfide superficially satisfactory as commercial salt readily soluble and reacts almost stoichiometrically with wastes contg. 150 ppm. hexavalent chromium or less. Some iron present in commercial salt and causes brown colloidal dispersion of sulfur and sulfides which can be coagulated by addn. of ferrous sulfate. If more than 150 ppm. chromium present, small amt. of strong oxidizing agent, e.g., permanganate, must be added to produce clear effluent. Ppt. settles slowly, particularly in shallow tanks, and not easily dried. When powd. commercial barium sulfide used as reducing agent, reaction slow and incomplete. Better results obtained if soln. prepd. If less than theoretical amt. of barium sulfide added to a soln. of chromate and soln. neutralized, all chromium may be pptd., but on standing, yellow soln. of chromate ion reappears. Complete reduction may be obtained by adding ferrous sulfate after neutralization with lime, as this reagent will react with excess chromate, barium, and sulfide ions, and will also coagulate heavy metal sulfides. Ppt. settles rapidly and readily dewatered to form firm cake. Finely divided iron reacts very slowly with dil. chromic acid solns. and concd. solns. make iron passive. Addn. of sulfuric acid or sulfates accelerates reaction. In lab. tests complete reduction of 250 ppm. soln. of waste chromic acid, to which sulfuric acid added, obtained in 4 hr. by treatment with steel scrap. Continuous-flow process, with period of retention of 6 hr., may be used. Copper deposited on iron and facilitates reduction. After treatment with scrap iron, soln. neutralized with lime and trivalent chromium pptd. with ferric and ferrous salts. Mixed ppt. settles more rapidly than chromium compds. alone, but not easily dewatered on vacuum filters, and best disposed of on sand beds or by lagooning. Reduction by liquid sulfur dioxide prohibited by its cost, but sulfur dioxide gas can be prepd. by burning sulfur. Gas bubbled through wastes, air bubbled through to remove excess sulfur dioxide and hydrocyanic acid, and trivalent chromium pptd. with lime. Sludge can be dewatered slowly on sand beds or on vacuum filters. Reduction by sulfur dioxide is most suitable method for recovery of saleable chromium compound, if soda ash or caustic soda used as neutralizing agent. If filter cake dried and roasted at 500°C. dense green β-chromium trioxide produced which can be used as pigment. Plant to handle 40,000–100,000 gal. chromium plating waste per 24 hr. now under constr. Can be adapted to use any of 4 processes described and will begin by using barium sulfide.—*W.P.R.*

Water Pollution by Distillery Waste. Y. K. R. Rao. Curr. Sci. **9:** 539 ('40). Offensive odor from Hall R. at Mandya found to be due to H_2S from waste wash waters from distillery using cane molasses. Gas not present in fresh waste but developed after storage for 5 days. Anal. of spent wash, after evapn. and drying at 100–110C°., gave following results: carbon, 6.0–7.0%; ash, 1.64%; potash, 0.7%; sulfur (as sulfate) 0.98–0.13%; and yeast (removed by centrifuging) 0.75%. Spent wash dild. in proportion of 1:1 or 1:2, and yeast, colloids and bacteria removed by addn. of 2% lime; dry ppt. on treatment with HCl gave off CO_2 but no H_2S. Filtration through Seitz filter removed remaining yeast and bacteria. Solids from evapn. of filtrate contained iron, calcium, potassium and sulfur. Suggested that H_2S produced by reducing action of enzymes in yeast on sulfates and sulfate-reducing bacteria may be contributory cause. This view supported by presence of large deposits of cupric sulfide formed on plates of analyzer of plant by action of free H_2S on hot copper plates and bubbling caps.

To avoid poln. of water by H_2S, wash centrifuged before distn. and yeast in spent wash removed by pptn. with lime and filtration. Economy achieved to be studied in each case.—*W.P.R.*

Treatment of Tannery Wastes With Flue Gas and Lime. H. B. RIFFENBURG AND W. W. ALLISON. Ind. Eng. Chem. **33:** 801 (June '41). Leather mfg. produces wastes contg. large quant. of colloidal and suspended matter difficult to dispose of due to tendency to clog sewers or pollute streams. Mixed waste from various tanning steps is black, somewhat viscous, pH about 7.5, over 17,000 ppm. of solids, avg. B.O.D. 13,000 and color over 65,000. Medium-sized tannery (about 300 hides per day) produces 60,000 to 75,000 gal. of total wastes per day, yielding as much as 11,000 lb. of solids unusually resistant to decompn. in streams. Recommended treatment is: Intermittent wastes liable to cause trouble, e.g., limes, bates, spent tan liquors and bleaches, stored together in basin with 24-36-hr. capac. Pumped from storage to mixing tank where flue gas, obtd. by tapping power plant chimney, blown through spider at bottom of tank until waste soln. nearly satd. and pH lowered to 6.7 to 6.4. Lime water added until soln. is basic to phenolphthalein; soln. is well mixed and allowed to settle, or is pumped to another tank where it is settled for about 3 hr., when supernatant liquor drawn off into another tank and treatment repeated. After settling 2 or 3 hr., supernatant is discharged to stream or sewer. Sludge is drawn from tanks, dewatered on cinder beds, and used as lawn fertilizer, high lime content increasing its value. Nearly 100 anals. showed:

DETERMINATION	RAW WASTE	AFTER FIRST TREATMENT	AFTER SECOND TREATMENT
B.O.D.	13,400	3,000	1,140
Color, ppm.	64,800	25,850	427
Total solids, ppm.	17,000	—	8,500
Lime in dry sludge, %	—	33.7	37.6

In treatment, calcium chloride can replace added lime to certain point.—*Selma Gottlieb.*

The Pollution of Texas Waters. B. F. WILLIAMS. Southwest W. W. Jour. **23:** 3: 35 ('41). Western ¾ of state receives less rainfall than 30″ usually required for farm and pasture land; hence, is dependent upon conservation measures to maint. water supply. Only polg. agency considered is salt water from oil fields. This menace threatens wells and streams in many areas, and rice irrigation and industrial supplies in Gulf Coast area.—*O. M. Smith.*

Grand River Sewage Dilution Problem. A. L. HANENBERG. Can. Engr.—Wtr. & Sew. **79:** 10: 40 (Oct. '41). Discussion of poln. by sewage in relation to diln. afforded by receiving stream, with particular reference to Grand R. conservation project. Daily per capita contribution of coliform bacteria varies from about 150 billion in winter to about 400 billion in summer and avgs. 225 billion; and amt. of org. matter contributed per capita per day, as indicated by first-stage B.O.D., may be nearly 0.22 lb. Oxygen content of receiving body of water, together with oxygen provided by re-aeration and by photosynthesis, must be sufficient to oxidize org. matter introduced. If oxygen insufficient, anaerobic reduction of org. matter occurs and offenisve compds. produced. According to U.S. Bureau of Fisheries, 5 ppm. oxygen necessary for maint. of normal fish life. Flows of 3.3 to 10 cfs. per 1,000 pop. suggested as vol. of water necessary for disposal of sewage by diln. Flow of 6 cfs. per 1,000 pop. would appear to be adequate if oxygen content of diln. water not less than satn. Area of Grand R. watershed above Kitchener main disposal plant at Doon estd. at 1,060 sq.mi. and area above Galt, 1,360 sq.mi. Mean annual pptn. 33″, 35% of which appears in Grand R. at Galt, remainder being lost by deep seepage, evapn. and transpiration. Avg.-size tree may pass off nearly 70 gpd. by transpiration. Observed flow at Galt varies from 49 to 30,090 cfs. Flows as low as 40 and 20 cfs. occurred for short periods at Doon. With latter, ratio of river flow to plant

effluent (avg. 4 mgd.) would be only 2.7:1. Surveys by Ont. Dept. of Health in '34 and '36 showed oxygen satns. as low as 6%, and, as result, secondary treatment adopted at Doon. Completion of Shand (46,000 acre-ft.) and Luther Marsh (10,000 acre-ft.) reservoirs will provide min. flow of 200 cfs. at Doon. —*R. E. Thompson.*

A Study of the Zinc-Polluted River Ystwyth in North Cardiganshire, Wales. J. R. E. JONES. Ann. Appl. Biol. **27:** 368 ('40). Study of river has shown that destructive effect of poln. by zinc on river fisheries may be as serious as that caused by lead mining. In river valley there are disused metalliferous mine workings which still continue to discharge water, heavily pold. with zinc salts and to less extent with lead salts, from open adits. Pollution caused by drainage of surface water from exposed dumps of mine refuse comparatively unimportant. Main stream of river at normal level carries 0.7–1.2 mg. of zinc per l. in soln. and trace to 0.05 mg. of lead per l.; and bed is silted up with broken rock, rubble and gravel carried down from mine workings. Main stream completely devoid of phanerogamic vegetation and submerged grass and bryophytic vegetation extremely scanty. Fauna limited to Insecta, Platyhelmia, and Hydracarina. Absence of fish directly associated with chem. condition of water, and absence of Mollusca and Malacostracan Crustacea also appears to be due to poln. Nature of insect fauna detd. by phys. nature of stream rather than by chem. condition, most abundant insects at all points being species characteristic of swift water and living upon or beneath stones. Certain species of insects appear to be very tolerant of poln. by zinc, and some species found living in most heavily pold. of streams of river valley. Rarity of planarians and absence of oligochaetes and leeches may be due to the scouring action of mine refuse and rubble of river bed upon sluggish soft-bodied animals.—*W.P.R.*

CONSERVATION AND IRRIGATION

Unusual Events and Their Relation to Federal Water Policies. W. G. HOYT. Proc. A.S.C.E. **68:** 211 (Feb. '42). Appears that indicated increase in activities relating to conservation and control of water can be ascribed largely to concurrent effect of following: (1) '30–'40 decade was characterized by deg. of nation-wide abnormality with respect to climatic and hydrologic conditions that has probably not been exceeded during past century; (2) impact of economic crisis with chronic symptoms that began in '29, and associated depression, brought about changes in political leadership as well as modifications in govtl. theory; and (3) belated nation-wide recognition that wastage of soil and water is genuine menace to national welfare. Unusual meteorologic conditions relate largely to droughts and floods. Drought in '30 had much to do with initiation of land-planning and water-planning activities as distinct federal function. Widespread disastrous floods resulted in extension of federal flood-control activities from navigable and interstate streams to include so-called "up-stream eng." as integral part of flood-control operations. Prior to '30 no single federal agency that devoted itself exclusively to water planning from national standpoint. Federal flood activities prior to '30 generally incidental to navigation and conducted largely as function of the Corps of Engrs. Flood Control Act of '38 authorized additional flood-control improvements in 19 separate river basins. Congressional recognitions of relation between land use and floods and necessity for co-ordinate land-use program for flood control increased flood-control activities in Dept. of Agric. Flood Control Act of '36 permitted installation of penstocks when chief of engrs. recommended it, whereas '38 act required such installation be made when recommended by Federal Power Com. Prior to '30 operation of most public water projects related chiefly to a single purpose. Since '30, profound change in federal participation in multiple-use water projects. Storage capac-

ity thus made available exceeds 80,000,000 acre-ft.—more than combined capac. of all reservoirs constructed for all purposes in U.S. prior to '30. Since '30 nation has witnessed expansion of soil and moisture conservation activities, as such, from research into a nation-wide action and educational program by two major federal depts. Hydrology has played important part since one of primary purposes of activities relates to development of dependable water supplies in regions where supplies not only scanty, but where, in general, prior development has used best of water. Increase in availability of basic meteorologic and hydrologic data relates principally to increase in no. of precipitation stations. May be added also numerous fact-finding projects in hydraulic labs. and exptl. areas relating to evapn., transpiration, wave movement, debris movement, suspended load, and others, either independently or jointly, by Corps of Engrs., Geol. Survey, Dept. of Agric., Bureau of Reclamation, TVA and other agencies.—*H. E. Babbitt.*

A Water Conservation Policy. W. L. STRUNK. Conservn. Volunteer **3:** 18: 1 (Mar. '42). Minn. water conservation policy roots from fact water is common denominator of practically all conservation problems and programs. Means control and distr. of water resources to to make them serve as many uses as possible before flowing beyond reach. Practical application must consider relative rights of all interests affected. Involves first learning then teaching to form policies establishing sound and completely integrated projects. Research and intensive study of sources, distr. and behavior of waters require broadest possible foundation and continuous pub. support. All appropriate state and federal agencies must be enlisted to gather data for basing program on broad lines with right principles. All waters must be studied and classified as to characteristics and possible uses to assure max. benefits to people. Full consideration must be given all values relating to agric, munic. and indus. needs, recreation, wild life, fishes and forests. Public dissemination of broad conclusions therefrom vital to program success. Dept. of Conservation must lead and aggressively pursue plan through schools, 4-H clubs, boy scouts, conservation clubs and other groups. Program discussed in greater detail under: (1) agric., (2) forests, (3) health and poln., (4) recreation, (5) wild life, and (6) sub-surface water.—*Ralph E. Noble.*

Water-Disposal Planning Techniques. WILLIAM A. WELD. Agric. Eng. **23:** 152 (May '42). Recent adaptation of stereoscopic delineation and anal. of natural drainage features on aerial photographs, as initial step in planning process, one of most promising developments in water-disposal technique. Hitherto, insufficient emphasis placed on correlation of water-disposal planning with land-use planning. Stereoscopic work benefits are: With min. effort and cost, provides accurate base map identifying all major drainage ways and field depressions. Data enables technician to plan water-disposal system with major land-use changes on first trip over land. High qual. planning assured because of guidance by natural pattern shown clearly. Type of study adapted to wide range of field conditions and variety of problems in conservation operation programs. This type of anal. may be used for: (1) action program on flood control and land-use projects; (2) prelim. investigations for drainage surveys; (3) correlation of highway erosion-control plans with water-disposal and land-use planning; and (4) water-disposal planning on individual farm basis, as natural drainage features identified and properly correlated with those on adjacent lands.—*Ralph E. Noble.*

Surface and Underground Waters of Ohio. WILBER STOUT, C. V. YOUNGQUIST AND R. E. LAMBORN. Ohio State Univ., Eng. Exp. Sta. Circ. 43 (Jan. '42). Industrial recovery, defense and munic. needs correspond with acute water shortage in certain areas. Chief sources are: surface waters, rock strata yielding little, and glacial drift with yield spotty. *Conservation of Ohio's Water Resources.* Avg. per capita urban and rural use, 80–100 gpd. Industrial consumption

enormous, ranging from 15 to 880 mgd. Latter could increase 10-fold. Use of sub-surface and surface supply for irrigation in agric. increasing. Irrigation speeds production and improves qual. of products. Water shortage serious because of increased use with rapidly falling water table. Best sources of supply from ancient river beds buried by interglacial drift. These too few, however. Less than 50% of rock sources yield adequate supply. Annual rainfall 38″. Author holds that real water conservation practice with $\frac{1}{2}$% avg. runoff will solve shortage problem. Recommends using every known method possible to restore water to ground. Farmer and foresters can do so naturally. Construction of dams in headwaters will help. Ranney system of reversion may be necessary as now practiced by Timken Co. which puts used water from 12 mgd. well, back underground. *Surface Waters of Ohio.* Because of their relative large quant., surface waters will continue principal source of supply for large municipalities and industries. Their larger development and control by reservoirs required as state grows in pop. and in ind. and agric. activity. About 3.6 million people, approx. $\frac{3}{4}$ in Ohio, obtain water from surface sources. Of almost equal importance is use of streams for san. and ind. waste disposal. They must remove sewage from 75% of pop. Hydroelec. power on large scale not feasible because of comparatively small fall (slope) and deficient well-sustained stream flow. Steam power production considerably but depends on surface water for condensing and cooling. Water availability deciding factor in such plant site selection. Author describes conventional eng. methods of measuring stream flow. Believes crux of Ohio water problem lies in fact although annual stream runoff ample for all needs, distr. throughout yr. unfavorable. Points to need for more uniform stream flow regulation through yr. by constructing reservoirs for low-flow control. At same time, reforestation and erosion control measures should be intensively continued, particularly on headwater areas, to arrest silting of reservoirs from erosion. Benefits over long period will greatly outweigh costs. *Underground Waters of Ohio.* Consist of: (1) those derived from consolidated rocks as sandstones, conglomerates, limestone, dolomites and shales; and (2) those from less compacted formations as glacial drift and stream deposits. Author describes the several geological formations in relation to their water qual. and quant. yielding capac. and their relative distr. in Ohio.—*Ralph E. Noble.*

Grand River Conservation. MARCEL PEQUEGNAT. Can. Engr.—Wtr. & Sew. **79:** 10: 36 (Oct. '41). Grand R. and its tributaries, Conestoga, Speed and Nith, drain area of 2,600 sq.mi. in thickly populated sections of Ont. Water supply of area depends primarily upon flow of river, Galt and Fergus obtaining water from wells drilled in rock and depending upon infiltration from river, Kitchener and Waterloo from wells in underlying gravel strata, and Brantford directly from river. Drainage basin about 120 mi. long and 10–40 mi. wide. In 180-mi. length of river there is drop of 1128′. Poln. of river, combined with serious reduction in flow in summer and flood menace in spring, brought about condition which necessitated remedial measures. As result of prolonged negotiations between municipalities affected and provincial and federal govts., which are dealt with in detail, concrete dam for regulation of river flow is approaching completion at Shand. This is first unit of Grand R. Conservation Scheme, first of its kind in Canada. Second unit at Luther Marsh being left in abeyance during war at request of federal govt.—*R. E. Thompson.*

Northern Wisconsin Swept by Floods of Unusual Intensity. ANON. Eng. News-Rec. **127:** 337 (Sept. 11, '41). Following 10 days of steady rain, deluge on Aug. 30, which amtd. to 15″ of rainfall at Hayward and 7–12″ at other points in vicinity, caused streams to overflow banks, damaged highways and railroads and carried out several power dams. Continued rain during following week maintd. streams at high level.—*R. E. Thompson.*

Reservoir System Helps Reduce Flood Hazards. ANON. Elec. World **116:** 6 (Sept. 13, '41). When worst flood since 1884 hit Eau Claire territory of Northern States Power Co. of Wis., Aug. 31, officials ordered all generators put on line to draw down water levels and provide for heavy runoff to reduce flood possibilities on lower Chippewa R. At peak, 20,000 cfs. recd. by reservoir system, while 8,000 cfs. released, thus reducing flood crest.—*Ralph E. Noble.*

Operating Experiences, Tygart Reservoir. ROBERT M. MORRIS AND THOS. L. REILLY. Proc. A.S.C.E. **67:** 569 (Apr. '41). (See Jour. A.W.W.A. **33:** 1294 ('41).) *Discussion. Ibid.* **68:** 161 (Jan. '42). EDGAR E. FOSTER: Although gen. principles of operating flood-control reservoir applicable to any watershed, details of operating plan must usually depend on characteristic features and requirements of each individual basin. Usually large industrial centers like Pittsburgh, subject to heavy flood loss, would be controlling point for reservoir operation, but authors have shown that navigation is of such importance on Monongahela R. that control point near center of basin must be selected. Storage reservoir can reduce downstream flood crests by 2 means: (1) storage until flood has subsided; or (2) delaying peak at site until flood crest of valley below has moved downstream. Flood on a river not simple summation of excessive areal runoff, but compound product of various peaks of tributaries that combine at different times and places. "Flood-wave" analogy should not be taken too literally. Writer believes that snow surveys should also be utilized to secure data of moisture content of snow cover if possibility that such cover can contribute appreciable proportion of flood runoff.—*H. E. Babbitt.*

The Effect of Mulching and Methods of Cultivation on Runoff and Erosion From Muskingum Silt Loam. H. L. BORST AND RUSSELL WOODBURN. Agric. Situation **23:** 19 (Jan. '42). Previous studies showed straw mulch at 2 tons per acre applied to cultivated surface controlled runoff effectively. Applied to soil surface, compacted and "sealed" by rains, controlled erosion but affected runoff slightly. Present study designed to investigate mulch action mechanics in erosion control and detg. importance of rain-drop impact and overland flow. Found approx. same deg. control from mulches supported 1" above sealed plot as on surface. Concluded, when plots surface mulched, interference with overland flow unimportant in curtailing soil loss. Eliminating destructive effect of rain-drop impact on soil surface, rather than reducing overland flow velocity, appeared major contribution of mulch. Quick removal of mulch during run, increased soil concn. in runoff 6-fold. Soil prepared at optimum moisture content sealed earlier than damp or dry; and suffered greatest runoff and high avg. soil loss. Dusty plots reacted similarly. Avg. runoff only 25% from 3 plots, cultivated damp and left cloddy, while about ⅓ of that from plots cultivated at optimum moisture content. Soil conserving tillage practices, however, must be based on crop response as well as their soil and water conserving properties.—*Ralph E. Noble.*

Regional Contrasts in Torrential Rainfalls Help to Explain Regional Contrasts in Erosion. STEPHEN S. VISHER. J. Geol. **50:** 96 (Jan.-Feb. '42). New data on rainfall intensity in U.S. reveal notable regional (reg.) contrasts in amts. of rain received and frequency of large falls in short periods. General southward increase in amts. in short periods shown in eastern half of U.S. South receives about 50% more water than North in brief rains, but, in hard rains of 8–24 hr., Gulf coastal region receives more than twice as much as northern part of North. Reg. contrast much greater in frequency of hard rains; deep South receiving large total from 10 to more than 100 times as often as North. Extensive comparable data on extent of soil erosion resulted from Soil Conservation Service surveys of eastern half of U.S. Despite many local variations in extent of erosion, correlated with soil, slope and land use, data reveal general southward

increase in erosion upon comparable areas. Detailed anal. of reg. erosional contrasts in Ind. summarized and followed by more general summary for rest of eastern U.S. Concluded that part of reg. contrasts in erosion correlate with frequency and intensity of hard torrential rains.—*Ralph E. Noble.*

Consumptive Use of Water for Agriculture. ROBERT L. LOWRY JR. AND ARTHUR F. JOHNSON. Proc. A.S.C.E. **67:** 595 (Apr. '41). (*See* Jour. A.W.W.A. **34:** 154 ('42). *Discussion. Ibid.* **67:** 1497 (Oct. 41). S. T. HARDING: Authors have included rainfall in water supply from which consumptive use is detd. This is desirable in results that may be used in both irrigated and non-irrigated areas. Consumptive use from irrigation separately from rainfall has been detd. for some areas served by Kings R., in Calif., values derived being about 1.7′ for orchards and vines and 2.0 to 2.25′ for areas mainly in alfalfa. Total annual effective heat for Fresno about 16,000 day-degrees, indicating general consumptive use of 3.4′. C. S. JARVIS: Became apparent in dealing with upper Missouri R. and entire Platte R. basins, that yield from headwaters and pptn. closely related for separate yr., pairs or groups of yr., such as decades, and up to total periods of record, whereas recorded discharges along middle valleys showed more and more marked deficiency as irrigated area and storage facilities serving such regions, became further developed. R. W. DAVENPORT: Relation between temp. and consumptive use detd. for only 28 areas and in published rept. mean annual temps. used instead of day-degrees. Conclusion to be drawn is that two methods of computing effective heat have compensating influences, that they lead to similar totals in day-degrees and are perhaps equally effective methods of correlating consumptive use to climatic conditions.—*H. E. Babbitt.*

Salts in Irrigation Water. RAYMOND A. HILL. Proc. A.S.C.E. **67:** 975 (June '41). Graphing diagram comprising 4 equilateral triangles arranged about common apex upon which plotted trilinearly percentages of 6 major ionic group constituents of water. Mineral character indicated by locations of 3 points. Subdivision of plotting area into 16 secondary areas serves as basis of classification of waters into types and subtypes. Use of method in proving mixtures and tracing ground water movements demonstrated. *Discussion: Ibid.* **67:** 1385 (Sept. '41). C. S. SCOFIELD: Value of geochem. classification applied to irrigation waters questioned. Nature of effects of salt constituents on soil and on plants reviewed. *Ibid.* **67:** 1490 (Oct. '41). HERMAN STABLER: Hill trilinear method of plotting compared with double-bar method. Desirability of grouping sulfates with bicarbonates rather than with chloride and nitrate as originally proposed by Palmer questioned. M. R. LEWIS: Since carbonate group concn. affects pH buffer capac. of water, and sulfate does not, appears more logical to group sulfate with chloride and nitrate. *Ibid.* **67:** 1957 (Dec. '41). LOUIS J. ALEXANDER: Relative concns. of 3 anion groups and relationship between (Ca+Mg) and (CO_3+HCO_3) made basis of proposed scheme of 5 classifications. W. D. COLLINS: Many of Hill data replotted, using double-bar method. Chem. arithmetic of salt balances in irrigated valley discussed, and caution in interpretation of limited data suggested. JOHN H. BLISS: Examples in use of saline waters on irrigated lands. Physical character of soil and frequency of flushing with good water important considerations. (*See also* Jour. A.W.W.A. **34:** 335 ('42).) —*W. F. Langelier.*

NOTE: *Pages 1585* et seq. *will be found immediately following the document beginning on the page facing.*

Progress Report No. 1 of the Committee on Survival and Retirement Experience With Water Works Facilities

THE formation of the Committee on Survival and Retirement Experience with Water Works Facilities resulted from the many requests for information relating to the actual life in service of the many items of property making up a water system, from those interested in their operation and management, municipal and financial administrators and utility regulatory bodies.

The committee was authorized by the Board of Directors of the Association at its January 1941 meeting and promptly commenced the mortality studies of facilities upon which this progress report is based. The committee has, since its beginning, had the active co-operation and financial support of the Institute of Water Supply Utilities. Subsequently, in November 1941, the New England Water Works Association voted to join in the study and appointed a committee to co-operate with that of the A.W.W.A.

Approximately 35 representative cities and private water utilities of the United States and Canada were invited to contribute the personnel and expenses of their organizations to canvass their records of installation and retirement of property units. With very few exceptions, these cities and companies generously agreed to donate and are continuing to furnish the personnel required to compile the records of amounts and dates of installation and retirement of property necessary to determine the actual facts indicating the length of lives, survivals and reasons for retirements of facilities in their plants.

The purpose of the committee's activities is to collect and arrange into readily available and usable form statistics regarding the age and amount of the principal elements of water works systems that have been retired

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A progress report submitted on June 24, 1942, at the Chicago Conference by E. H. Aldrich, *Supervising Co-ordinator* of the Committee, Cons. Engr., Newsom and Aldrich, Engineer-Consultants, New York. Committee personnel is listed on page 174 of the *1942 Membership Directory*.

and the amounts of various-aged facilities which have survived. This study concerns itself not only with the determination of the number of years of service which have been rendered by items of property replaced or abandoned, but also with the determination of the number of years of service of the elements of plant still in use. An analysis of the conditions dictating retirements and the reasons why experience in one plant may be unusual and at variance with those in other plants forms another feature of the study.

Grouping of Facilities

Water works facilities lend themselves generally to division into two groups: one consisting of items of like kind occurring in large numbers in all plants, and the other consisting of a few individual units in a system

TABLE 1

*Scope of Committee Activity**

	PLANNED	COMPLETED	REMAINDER
Number of Cities Studied	35	19	16
Total Population	10,000,000	4,000,000	6,000,000
Miles of Mains	20,000	5,800	14,200
Number of Valves	30,000	16,000	14,000
Number of Services	900,000	75,000	825,000
Number of Hydrants	80,000	8,000	72,000
Number of Meters	1,000,000	100,000	900,000

* Figures approximate.

which are influenced as to type, size and length of useful life by the particular conditions under which they operate. Mains, meters, services, valves and hydrants form the major items of the first group, and dams, reservoirs, intakes, wells and the like are items in the second group.

The detailed report* reflects the studies so far made of items included in the first group, termed Group A. The scope of the work of the committee as originally contemplated regarding this group and the part covered in this report, are set in approximate amounts in Table 1.

In explanation of the table, there must be mentioned the fact that two cities, Detroit and Los Angeles, make up, generally, more than 50 per cent of the total facilities planned to be studied and the compiling of the data covering them has not yet been completed. Further, the summary of work done covers only fully identified items of property and represents only records of facilities substantial enough to form the basis for a study.

* Complete progress report is on file in the A.W.W.A. office.

Items such as cement-lined cast-iron pipe and copper services, of relatively recent development, have not yet had a length of life sufficient to predicate a study or form a curve of any practical benefit, although it is the intent to include in the final report a summary of some of such facilities. In many of the small cities studied, the retirements have either been so few, or the period of record so short, as to preclude their inclusion in this progress report, but they, likewise, will finally be summarized.

Considerable data are at hand and it is expected that additional data will follow relating to the experience with Class B facilities, none of which studies has been completed to date. Likewise, little has been done in summarizing the reasons for retirement or the individual experiences of the various plants affecting the useful life in service.

Because of the large amount of detail work required, a study such as this takes a tremendous amount of time and effort on the part of all concerned. Much has been accomplished by participants, but a great deal of work remains to be done to complete the program laid down by the committee. War activities have, of necessity, restricted and slowed down the efforts of those cities actively involved therein.

Greater Vancouver Water District Mutual Aid Plan

By William Powell

THE Greater Vancouver Water District is a mutual aid organization, supplying water to thirteen governmental authorities with a total population of 340,000, spread over about 300 sq.mi. The largest authority has a population of 275,000, the smallest about 300. The district owns, operates and maintains 103 mi. of supply pipe and the distribution pipes of its constituent members contain 1,200 mi. of pipe above 4 in. in diameter. The capital value of the district's pipe lines and conduits is about $11,000,000 and the cost of replacement of the distribution system would be not less than that amount.

War damage as it affects utilities may be considered under two headings—sabotage and air bombing. Every effort was made to shift the responsibility for sabotage and air raid damage to the military or the police or any other body which would receive it, but no one would accept it. Therefore, from the date that war was declared, September 3, 1939, the district has taken its own precautions against sabotage and air raids and organized for prevention and for cure as has seemed justifiable.

Distance from Vancouver makes the actual physical connection of a grid water works system with other cities impossible, but within the district emergency inter-connections have been made between high and low level zones and pump set-ups have been installed between low and high level areas. The pumps are portable, designed for about 1–2 mgd. capacity, are driven by Mercury engines and can be installed in the provided set-ups in about 45 min. These are not maintained as fire-fighting units but rather to provide domestic water throughout the area in the event that two out of the three sources of supply should be "blitzed."

Early in the war an engineers and superintendents group of the Civilian Protection Committee was formed from personnel in the cities and municipalities surrounding Vancouver. A list of all available water works

A paper presented on May 8, 1942, at the Pacific Northwest Section Meeting, Walla Walla, Wash., by William Powell, Greater Vancouver Water Dist., Vancouver, B.C.

machinery, as well as lists of all plant and equipment, tools, pipes and valves, was made. In accordance with its responsibilities and its financial resources, each authority collected and stored such water works material as it seemed might be needed within its own boundaries or which could be loaned to its neighbors in case of dire necessity. A list of the key men in each municipality was prepared and these key men had a list of telephone numbers of all their employees or of men who lived in the area who could be called on in emergency. Priority of telephone service was given to a few men on each telephone exchange so that a red light on a marked number called for immediate reply irrespective of the fact that the rest of the board might be covered with red. The dial phone system has not yet been completed in Vancouver.

An excellent air raid precautions organization exists, but as a general rule men trained in water supply work are not encouraged to join it or the reserve army unit. Enlistment in guerrilla bands, however, is not debarred. In the event of emergency others may be trained to do A.R.P. or army work, but only years of experience make it possible for a man to know where, how and when to operate a valve in a water system.

Applications of Mutual Aid

In all thirteen cities, municipalities or villages with the large network of pipes, saboteurs can strike singly or in a number of places at the same time, probably directing their efforts against a war construction industry or perhaps incendiarism against the city as a whole. This sabotage would probably hit in only one or two of the areas at once, so that the water works personnel of one municipality could readily be called to assist with the repair work of another. This would apply also to damage caused by air raids, but there is a likelihood, if raids occur, that damage would be of much wider extent. This damage can be repaired only in daytime for, as the experience of London and Great Britain indicates, it is more satisfactory to make permanent rather than emergency repairs to a bombed water main. It will be expected then that the untouched will come to the aid of the harassed.

It will also be expected that water works stores will be made available in emergency to those in trouble. Emergency equipment, pumps and portable chlorination plants for example are kept in stock by the larger organizations and this equipment will, no doubt, be available to all as needed.

Distances between other coastal cities in British Columbia are great—Nanaimo is about 40 mi. away, Victoria, about 90 mi. and Prince Rupert nearly 400 mi. They could all be organized into a mutual aid plan, but

so far no effort has been made to do so. Although these distances may seem great, today men and materials can be quickly dispatched by plane to serve in an emergency.

In this same respect the possibilities of international mutual aid should not be overlooked. Seattle and Vancouver are 135 miles apart but the roads are easily negotiable at 50 or 60 mph.

The wooden houses and extensive spread of war industries are similar in Canada and the United States. A two-, four- or six-hour fire or many of them may be beyond the capacity of the water service available or of the capabilities of the home water works men to maintain. Should each group of cities be handicapped by international red tape and made to produce an untouched photograph on a passport properly viséd before crossing the boundary at Blaine?

If there were no difficulties in water supply there would be no necessity for the existence of water works engineers, superintendents and workmen. Any person could do the job. But since water works engineers are necessary, it would seem that despite the formality of a border they should be able to develop a method to afford international mutual aid in water service during the emergency.

That some progress is being made in international relations is evidenced by an article in a U.S. weekly in April, which states: "The United States-Canadian Border is dimming like a Cheshire Cat. Last week the two countries lifted restrictions on the seasonal migration of farm labor and machinery." Perhaps the same may be done with aid in water service.

Take a Personnel Inventory Now

Selective Service Advice on Long-Term Personnel Planning

MANPOWER is a most important strategic material today. Every employer should make a prompt inventory, appraisal and analysis of the manpower in his own plant as he would inventory his stock pile. In order to keep production going and at the same time furnish men for the armed forces, industry should now establish an orderly replacement program.

To secure temporary deferments for essential men while he is training women, young men, older men, men physically handicapped or those with a high degree of dependency, the employer should know the fundamental principles in the operation of his local Selective Service Board. Certain steps should now be taken by each employer. He should know how many men on his payroll are between the ages of 20 and 45. He should investigate the classification of every one of those men. On the basis of such an inventory he should prepare to plan ahead and train men for replacement of those who must necessarily enter the armed forces if we are to have the sort of army which can win the war.

Deferments Temporary

Deferments, granted so that employers may train women or men not liable to early induction, are temporary deferments; they cannot exceed six months and in many cases may be for only 30, 60 or 90 days. The Army today has to train a bomber pilot within a period of eight months to operate a very technical machine with an instrument board which puzzles even an expert. Why, therefore, should industry insist that it assume that it can take two or three years to train men for industrial tasks not nearly so complicated?

The fundamental purpose of every deferment of a registrant is to allow an employer to train a replacement. Only in a few rare instances can an

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employer expect to have these temporary deferments continued for more than the six-month period. These are only in cases where an abnormally long period of training is required for a replacement and the eight months now required to turn out a bomber pilot is something to remember in this connection.

Employer's Responsibility

Employers may seek the deferment of their necessary men with or without their consent. Here is how they go about it.

On page 3 of the Selective Service Questionnaire (Form 40) which is sent to each registrant before he is classified is the following:

"INSTRUCTIONS: *If your employer believes that you are a necessary man in a necessary occupation, it is his duty to fill out form 42A requesting your deferment. You may also attach to this page any further statement by yourself which you think the local board should consider in determining your classification. Such statement will then become a part of the questionnaire.*

This statement appears on all the questionnaires distributed during the past six months. The fact that the Selective Service System now specifically mentions the filing of Form 42A as the manufacturer's duty is a clear indication of the Selective Service System view of the responsibility of each employer in this matter.

The employer can secure Form 42A at the local board and the local board will consider the employer's request when the form is properly filled out and signed.

If such request should be denied because the man, after consideration of the claims offered for him, is not considered to be indispensable to the company's operation, and is needed more in the armed services, the local board will advise the employer of its refusal of such an occupational deferment. The local board does this by sending to the employer, at the same time it notifies the registrant of his classification, a Form 59.

Appeal May Be Made

For ten days after Form 59 is mailed by the local board to the employer, the employer can appeal the registrant's case. The registrant will not be ordered to report for induction during this ten-day period.

To make an appeal the employer must simply sign his name to the Form 59 which he has received, and return it to the local board; or if the Form 59 is not received from the local board, any written request will have full value to make such an appeal effective. When Form 59 is returned by the employer the appeal procedure becomes automatic.

All necessary forms are available at the local board in the employer's immediate vicinity or at the office of the State Director of Selective Service.

If the local board and the appeal board deny the appeal for the occupational deferment of a key man, the employer may then bring the matter to the attention of the State Director at the State Selective Service Headquarters, with the request that the case be reopened or appealed by him to the President.

Definite Duty of Employer

A double duty rests upon the employer. He should personally know what his manpower situation is. He should not leave the job to a minor employee to decide who is necessary. The employer who delegates the task of filing a request for deferment to a clerk, the executive who does not make a complete inventory of his whole plant today, is negligent. Likewise, the employer who files requests for deferment of men who can be replaced by women, or others, is keeping reinforcements out of an Army which is battling for us all. The employer engaged in essential war production who has been required to expand his plant greatly and who then fails to request deferment for his key men is also negligent.

A good rule to follow is: Don't ask deferments for any men who can be replaced by training another individual not likely to be eligible soon for service in the armed forces.

Make an inventory, request deferment for any man whose immediate going into the armed services would retard production of vital war material or other services essential to the war effort, or who is needed to maintain national health, safety and interest.

Only when an employee is working in a critical occupation within an essential industry should a Form 42A be filed for his temporary occupational deferment.

Replacements Necessary

An inventory within a man's own plant is called for, as is an appraisal and analysis of the manpower in the community. Many a man over 45, or physically handicapped, or many a woman can do that job that the 23-year-old boy who took a 12-week course at a learn-quick school is now doing.

There are not more than sixty million people in this country who are capable of effective productive effort. These men and women represent our total manpower available to win the war. They must do everything that must be done in a total war: maintain transportation, communications and utility systems, maintain public services, grow food for ourselves and our allies, mine the metals and produce the raw materials, fabricate and produce the amount of consumers goods necessary to maintain even a restricted national life and the supplies, weapons and munitions of war;

also, most important of all, they must provide the men who land on strange shores in far places, the men who carry the fight to the enemy on a multitude of far-flung frontiers. The rest of the population who mine raw materials and produce the weapons with which these men fight must be a self-disciplined team working in unity. The individual personal convenience, comfort or pleasure, or the convenience and ordinary leisurely replacement programs of the employer, will have to be given progressively less consideration as the war gets tougher and the casualty lists grow.

When we hear of the big armies we are going to raise, we must all remember that it takes at least five men or women to produce what they eat, use, fight with and wear. With less than sixty million "availables" in this country, those figures are worth deep consideration.